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A Preliminary Summary of
Progress and Plans

VEGETABLE RESEARCH

of the United States Department of Agriculture
and
in cooperation with
State Agricultural Experiment Stations

Prepared for the Department's
VEGETABLE RESEARCH AND MARKETING ADVISORY COMMITTEE

for its 16th Annual Meeting
Washington, D. C.
February 6-9, 1961

1960

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- This progress report is primarily a tool for use by advisory com-
• mittee members in developing recommendations for present and future
• research programs and by USDA administrators for developing, coordi-
• nating, and evaluating research plans. Included in it are summaries
• of research done during the past year. Some are tentative results
• that have not been tested sufficiently to justify general release.
• Such findings, when adequately confirmed, will be released promptly
• through established channels. Because of this, the report is not
• intended for publication and should not be referred to in literature
• citations. Copies are distributed only to advisory committee members,
• research administrators, and others having special interest in the
• development of public agricultural research programs.
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 - The report also lists publications of research results issued
• during the year. Current agricultural research findings are also
• reported in the monthly USDA publications, "Agricultural Research"
• and "Agricultural Marketing."
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UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.

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FUNCTIONS OF ADVISORY COMMITTEES

The Vegetable Committee is one of twenty-four commodity and functional committees of the U. S. Department of Agriculture established pursuant to Title III of the Research and Marketing Act of 1946. Functions of the members of these committees include:

1. Acquainting themselves with the problems of producers, processors, distributors, and consumers, and presenting them for committee consideration.
2. Reviewing the current research and marketing service programs of the Department and recommending adjustments, including terminations, in the current program in order that available funds, personnel, and facilities will be used on problems of greatest importance.
3. Recommending new work or expansion of current work and indicating relative priority of such recommendations, when the current program is insufficient to develop solutions for important problems.
4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested groups and organizations and encouraging the wider and more rapid application of the findings of research.

The committees perform an important function in advising with respect to the development of the Department's research and marketing service programs. However, committee members recognize that the development of budgets and the implementation and administration of research and marketing programs are responsibilities of the Department.

A progress report similar to this one is prepared for each committee. The areas of the other twenty-three committees are:

Citrus and Subtropical Fruit	Livestock
Cotton and Cottonseed	Oilseeds and Peanut
Dairy	Potato
Decidious Fruit and Tree Nut	Poultry
Economics	Refrigerated and Frozen Products
Farm Equipment and Structures	Rice
Food and Nutrition	Sheep and Wool
Food Distribution	Soils, Water and Fertilizer
Forage, Feed and Seed	Sugar
Forestry	Tobacco
Grain	Transportation
Home Economics	

This progress report was compiled under the leadership of Roy Magruder, Executive Secretary, Vegetable Research and Marketing Advisory Committee, Office of the Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

CODES TO DESIGNATE UNITS
CONDUCTING RESEARCH

AGRICULTURAL RESEARCH SERVICE (ARS)

Farm Research Divisions

AE	. . . . .	Agricultural Engineering
ADP	. . . . .	Animal Disease and Parasite
AH	. . . . .	Animal Husbandry
CR	. . . . .	Crops
ENT	. . . . .	Entomology
FE	. . . . .	Farm Economics
SWC	. . . . .	Soil and Water Conservation

Utilization Research and Development Divisions

EU	. . . . .	Eastern
NU	. . . . .	Northern
SU	. . . . .	Southern
WU	. . . . .	Western

Home Economics Research Divisions

CH	. . . . .	Clothing and Housing
HHE	. . . . .	Household Economics
HN	. . . . .	Human Nutrition

AGRICULTURAL MARKETING SERVICE (AMS)

Economics and Statistics Divisions

AEC	. . . . .	Agricultural Economics
AES	. . . . .	Agricultural Estimates

Marketing Research Divisions

MD	. . . . .	Market Development
ME	. . . . .	Marketing Economics
MQ	. . . . .	Market Quality
TF	. . . . .	Transportation and Facilities

FCS	. . . . .	FARMER COOPERATIVE SERVICE
FAS	. . . . .	FOREIGN AGRICULTURAL SERVICE

FOREST SERVICE (FS)

Forest Research Divisions

FDR	. . . . .	Forest Diseases
FER	. . . . .	Forest Economics
FFR	. . . . .	Forest Fire
FIR	. . . . .	Forest Insect
FMR	. . . . .	Forest Management
FPR	Forest Products Utilization
FMR	Range Management and Wildlife Habitat
WMR	Watershed Management

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I. FARM RESEARCH

A. Breeding and Genetics

1. PLANT INTRODUCTION AND DEVELOPMENT

CR

Problem: Introduce germ plasm from foreign centers of origin to increase genetic base needed in vegetable variety improvement and its preliminary evaluation.

Program: Emphasis has been placed on the introduction and screening of vegetables for genetic characters needed in the improvement of existing commercial varieties, and on the introduction of improved varieties not yet tested in the United States. This involves locating sources of common disease and insect resistance, color, firmness, good quality of flesh, and other characters needed by breeders to improve our present day vegetable varieties to meet production needs and changing consumer demands. The equivalent of 5 professional man-years are required for vegetable introduction and development.

Progress: The following 828 vegetable introductions were received from foreign sources, and distributed either to the four Regional Plant Introduction Stations or directly to research workers in State or Federal programs:

Allium cepa (onion)	76
Allium species	64
Asparagus species	5
Brassica species	69
Capsicum species	218
Citrullus vulgaris (watermelon)	21
Cucumis melo (muskmelon)	48
Cucumis species	34
Cucurbita species	17
Daucus carota (carrot)	33
Ipomea batatas (sweetpotato)	22
Ipomea species	3
Lactuca species	15
Lycopersicon esculentum (tomato)	69
Phaseolus species	70
Pisum sativum (peas)	51
Raphanus sativus (radish)	36
Spinacia oleracea (spinach)	8
Other vegetables	65

Usually the items distributed are basic materials for vegetable breeding, but a few are intermediate breeding lines of known value. Some are commercial varieties from other countries. During the year rather extensive collections of the two latter categories were obtained by a

qualified plant explorer travelling in Western Europe. This material is now being evaluated at the four Regional Cooperative Plant Introduction Stations where seed increase and plant evaluation take place prior to distribution. In addition to recording the horticultural characteristics of the vegetable introductions being evaluated and increased, the work of the four regional stations has been expanded slightly to include the screening of specific materials for troublesome diseases. This enables the regional stations to offer germ plasm of known value to the plant breeders of the country. Examples of such activities are the screening of eggplant introductions at the Northeast Regional Station for resistance to *Verticillium* wilt in eggplant, leaf-spot resistance in pepper at the Southern Regional Station, and a cooperative program in the North Central Region to screen tomato introductions for several diseases.

Plans: Introduction of vegetables will continue. During the year explorations for new germ plasm will be conducted in the Union of South Africa and in Iran, Afghanistan, Pakistan, and India.

Pathological programs being initiated include the evaluation of melon and other vine crop introductions for resistance to gummy stem blight at the Southern Regional Station and the screening of all bean introductions for the presence of seed-borne virus diseases at the Western Regional Station.

2. BREEDING AND GENETICS

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Problem: The vegetable industry is dynamic and vegetable breeding research must precede the extensive use of new variety by periods of 10 years or longer. Present needs include better adaptability to mechanized production, modern processing, and higher quality and greater nutritional value for fresh and processing markets. In addition to being high yielding and of high quality modern vegetable varieties must be bred with resistance to specific diseases, insects, nematodes, and physiological disorders.

Program: This is a long-term program involving both basic and applied research, with increasing emphasis on the basic phases and more reliance on commercial and State research to provide the local application. About 21 professional Federal man-years are devoted to this research at Beltsville and 11 field locations in 12 States. There is both formal and informal cooperation with State personnel and formal cooperation with grower organizations, food processors, common carriers, seedmen, and other private agencies.

Progress: Bean and Pea Breeding. Great Northern 1140, the new early maturing, high-yielding, mosaic- and rust-resistant dry bean was formally released in February 1960 by the USDA and the Montana and Idaho Agricultural Experiment Stations and is now available to western

bean growers. Under commercial conditions in Idaho in 1958 and 1959 it outyielded the other Great Northern varieties by about 15-20%. It is widely adapted to the bean-growing areas of Idaho, Montana, Nebraska and Wyoming.

Seaway, a new, early mosaic-resistant pea bean was jointly released March 1960, by Michigan State University and USDA principally for Michigan and New York growers. It matures 8-12 days earlier than Sanilac and 12-18 days earlier than Michelite, the standard pea bean variety.

In seven years of testing, Seaway averaged 34.2 bushels per acre, Sanilac 37.5 bu. and Michelite 33.8 bu. per acre. With its introduction, growers now have an early, a medium, and a late maturing variety to fit various farming situations.

It was determined that Michelite, released in 1938 as a mosaic-resistant variety, consisted of a mixed population; 50% of its plants were resistant and 50% susceptible to common mosaic. An improved Michelite having 100% resistance has been selected.

Fusarium root-rot resistance of PI 203 is being incorporated into snap and dry types and the progenies are being tested in natural and artificial Fusarium infested soils in Washington.

In tests at the Ohio Agricultural Experiment Station the Refugee types, including B2971-1-1, B3076, B3088-1, B3260-1 and B3281-2-1, all derived from crosses where Corbett Refugee was used as a parent, have resistance to the potato leaf hopper.

Extender is an all-purpose dark green pod type introduced January 1, 1959. Growers purchased over 300,000 pounds of Extender for green snap bean production during 1960.

The fresh, canned, and frozen beans are rated for quality in comparison with Blue Lake pole bean. A total of 17 lines out of 309 at Charleston were classed either as good as, or superior to, Blue Lake. Factors considered were color, firmness, skin slipping, clarity index, fiber and flavor.

Of the 3 green-seeded, downy mildew-resistant Fordhook lima types tested in the East on a large scale in 1959 only one (1656) is worth retesting.

Satisfactory progress continues in the development of resistance to downy mildew strain B in both the Early Thorogreen and Fordhook types. The source of resistance is Piloy, a red-seeded lima bean from Guatemala (PI 189403).

In greenhouse tests, all commercial varieties and most PI introductions were found susceptible to stem anthracnose of lima beans except PI Nos. 199,791 from British Guiana and 186,984 from South Africa. Resistance from these 2 lines is being incorporated into downy mildew-resistant Thaxter and Fordhook lima bean types.

Cabbage Breeding. Badger Shipper, the first club-root resistant variety of cabbage to be produced in this country, was introduced by the United States Department of Agriculture and the Wisconsin Agricultural Experiment Station. This variety is resistant to the most prevalent strain in many cabbage-growing districts in this country, but not to a strain occurring in Prince Edward Island, Canada. This new variety carries resistance also to cabbage yellows and cabbage mosaic.

Determinations made from the spring crop showed an ascorbic acid content ranging from 30.6 to 71.8 mg. per 100 gm. fresh weight basis. The average was 47.9 mg. per 100 gm. The highest content was from B944, a cross of Volnot x Globe. The fall and winter crop averaged 49.6 mg/100 gm. on a fresh weight basis, with a range of 31.0 to 74.4 mg. A selection from B914 from a cross of Madison x Early Round Dutch gave the highest reading.

Pollen collected on the day of anthesis and on each of the four following days germinated on improved artificial media 64.2, 42.6, 36.2, 30.1, and 2.4 percent respectively.

Several apparently male sterile plants were found in commercial fields of Round Dutch that bolted in the spring after a long cold winter. They had depressed anthers that were not shedding pollen. Seed started forming where pollination was carried out from normal plants. The plants were moved from the field to the screen house where anther development improved to normal size and viable pollen was produced. This type of male sterility might prove to be of value.

Carrot Breeding. The objectives of the carrot breeding project are to develop improved varieties and hybrids of carrots for processing and for fresh market; to find and incorporate disease and insect resistance; and to determine the inheritance of specific characters including those relating to the production of seed.

Dark orange colored roots were selected and a small increase of seed was made to test for horticultural characters. Screening for disease resistance is being done and selections made of roots resistant to aster yellows, Alternaria, and Cercospora leaf spot.

One important phase of carrot research is the development of male-sterile lines for production of hybrid carrots. Work is under way on inheritance of male-sterility, carotene content, quality, bitterness, and other characters, for fresh market as well as for processing.

Lettuce Breeding. Backcrosses were made between downy mildew-resistant plants and individual plants of a number of varieties of Great Lakes type. Backcross progenies from these were tested in the greenhouse for mildew resistance. Seed from more than 200 resistant individuals was obtained.

About 200 selections were made at Brawley in advanced breeding lines of head lettuce for the purpose of improving their horticultural qualities. This material is about equally divided between Imperial types and Great Lakes types. Among Romaine or Cos varieties, 54 selections in advanced breeding lines were made cooperatively with California, Texas, and the industry. About 275 selections were made from all types with special reference to slow bolting.

Selections for big vein resistance are being made.

In inheritance studies genetic-based male sterility appears to be inherited as a simple recessive. The inheritance of a corolla character also appears to be controlled by a single gene. Principles of quantitative inheritance applicable to lettuce are being studied in another species, Collinsia heterophylla.

About 4000 acres of Valverde, a downy mildew-resistant variety released in 1958, was planted during the 1959-60 growing season in the Lower Rio Grande Valley. It has been moderately successful. Head sizes in many instances were not as large as desirable, and the seed stalk frequently extended into the mature heads to objectionable lengths. Carlot shipments have increased from 373 in 1959 to 2,756 through February 24, 1960 and the breeding of Valverde appears to have saved the industry in that district.

Muskmelon Breeding. The objectives of the muskmelon investigations are to develop new, widely adapted, productive, high-quality varieties resistant to such diseases as powdery mildew, downy mildew, alternaria blight, crown blight, virus mosaic, root rots and vascular wilts and to develop information on the nature of certain diseases and methods for their control; to develop information on the genetics and breeding of muskmelons, to learn the causes of the crown blight complex and means for its control.

Selection for combined resistance to crown blight and powdery mildew was continued in the F₆ and F₇ generations from the cross 36486 x 45 x 450. Three of the selected lines were grown at Brawley, Meloland, and Davis, California, respectively, for seed increase. These lines had dry nectaries, a new but unwanted character associated with resistance. Only the line increased at Brawley seemed worthy of trials in larger plots and the occurrence of dry nectary forced the abandonment of many otherwise superior inbred lines from the cross 36486 x 45 x 450. Genetic studies indicated that the dry nectary character is a new mutant that

occurred in an early generation inbred from the cross (36486 x 45 x 450). The character, heretofore unknown in the muskmelon, has not been found in direct descendants of the ancestral lines.

Breeding lines of powdery mildew-resistant muskmelons were tested in commercial fields at Yuma and Parker, Arizona, in cooperation with the Arizona Agricultural Experiment Station. Five of these lines merit repeated trial in their present state.

Testing of muskmelon breeding stocks continued for resistance to the root-rotting fungi, most prevalent being Rhizoctonia solani, Fusarium solani, and Pythium aphanidermatum. Excellent results were obtained with the first of these; moderately-good results with the second, and poor results with the third. The aim of the tests was to determine: (1) whether resistance to one or more root-rotting fungi is correlated with crown blight resistance; and (2) the feasibility of incorporating resistance to one or more of these parasites into the breeding program.

Ascorbic acid (vitamin C) analyses of melon fruits averaged 37.0 mg. per 100 gm. fresh weight and ranged as high as 70.3 mg. Values for ascorbic acid are higher than usual, not because of seasonal effects, but because more effective screening in the past eliminated most of the fruit with soluble solids under 10 percent. The 3-way correlation between high soluble solids, high orange color, and high ascorbic acid was maintained. Some preliminary determinations were made on carotene.

The yg₁ leaf marker gene, determining yellow-green color, is being placed in several of our breeding lines by means of repeated backcrossing, with a view to using them as the female parent in the production of F₁ hybrids. A study is in progress to determine if oblong fruit shape and monoecious flower type are linked, pleiotropic, or independent in expression. The monoecious condition results in greater cross pollination than does the typical andromonoecious condition. If good round or oval monoecious lines can be developed which carry a marker gene such as yg₁, hybrid seed could be produced much more cheaply than by hand emasculation and hand pollination.

Onion Breeding. The hybrids Granex and White Granex have almost completely replaced the lines previously grown in Texas, but the pollen parents do not have resistance to pink root. Consequently, resistance to pink root is being incorporated into both pollen lines. A small increase of seed of pink root-resistant TEG 951 C, the pollen parent of Granex, was made at Beltsville.

Shallot lines with pink root-resistance are being developed and should be ready for release within 2 or 3 years. Plant introductions of Allium cepa and related species are being screened for pink root-resistance and for possible use as breeding material. Botrytis squamosa caused heavy losses last year in the bulb crop in the Lower Rio Grande Valley. Work is under way to find sources of resistance and a dependable method of

testing for resistance to this disease. New types of bulbs are being developed for the canning and processing trade.

The fundamental nature and inheritance of resistance to pink root is under investigation. Isolates of the organism have been obtained which will speed up the reaction in the screening pans in the greenhouse.

Work on the incorporation of pink root-resistance into the northern or long-day types and screening for resistance is continuing in California, Colorado, Iowa, Michigan, Wisconsin, Texas, and Oregon. Field-screening plots are maintained in Texas, Oregon, and Wisconsin.

A collection of economic species of Allium is under way at Beltsville and in California and Idaho. Interspecific crosses have been made with Allium cepa. So far, F_1 interspecific hybrids have been made between A. cepa and A. fistulosum, A. galanthum, A. drobovii, A. vavilovii, A. pskemense, and A. oschanini.

Spinach Breeding. Small isolation blocks of "all female" lines homozygous immune from races 1 and 2 of blue mold were produced. From 1/4 to 5 lbs. of seed were obtained with 7 lines in the field. Male plants did not appear in the field increase plantings. These 7 lines are being increased on a larger scale to (1) obtain stock seed; (2) study the problems involved in the maintenance of "all female" lines; and (3) determine their feasibility in spinach hybrid seed production. Combining ability trials with the "all female" lines and 2 tester lines have been established.

Seed increases of line #214, highly resistant to spinach blight, are planned for possible early release to the seed trade.

At Crystal City, Texas, progenies of individual plant selections from several apparently white rust-resistant plant introductions and from F_1 and F_2 populations, from crosses between these selections and blue mold-resistant lines were screened for white rust resistance in the field. Progenies of the resistant F_1 and F_2 populations have been rescreened in the greenhouse and the survivors are being used for further inbreeding and outcrossing to blue mold-resistant lines.

Sweet Corn Breeding. In productive hybrids adapted to the South-east resistance to the corn earworm is being combined with high sugar content, desirable ear appearance, and resistance to helminthosporium leaf spot. A possible use of diploid parthenogenesis in breeding is under investigation. Two presumably (protected but unpollinated) parthenogenetic ears were obtained. One was a Kiawah inbred. The other was on a male-sterile plant of a white x yellow kernel cross. Segregation for kernel color was 173 yellow to 171 white, obviously the gametic 1:1 ratio. Plants from the yellow kernels will be (1) protected without pollination, (2) self-pollinated, and (3) crossed with pollen from white-kernel plants. If the kernels prove to be

homozygous yellow this would provide critical evidence for their parthenogenetic origin.

Three plantings from seed acquired from NE-32, the Northeastern Regional Project, have been self- and inter-pollinated. Several lines secured in this way will be examined for resistance to the corn earworm. All major inbred lines are being converted to male sterile and fertility restorer lines through continued backcrossing. M98 was the only VBL inbred found to contain fertility restorer genes. P39M94T5 x M98 produced 4 completely male-sterile, 6 slightly fertile, 2 moderately fertile plants, plus 1 plant with nearly normal pollen development.

The sugar content of normal inbred ears at 25% dry matter ranges between 4.1 and 7.75%. The sugar content of shrunken, sh²su, inbred ears at 25% dry matter may be as much as 10% and the sugar is retained much better than in non-shrunken, sh²su, ears. Dry kernels of 17 sh² lines will be examined for sugar content and for modifications towards the normal to provide increased viability.

Sweetpotato Breeding. Development of new, highly productive, disease-resistant varieties possessing superior edible, nutritional, horticultural, and reproductive characteristics, and adaptable for fresh market, canning, freezing, or other utilization, is the primary objective of this research.

Approximately 10,000 controlled pollinations, utilizing over 50 selected parental lines, were made and 7,000 seeds have been harvested. About 4,000 additional seeds have been obtained from open pollinations (in the greenhouse) of several prolific parent lines.

Nineteen selections were canned and evaluated at Beltsville through cooperation with the Quality Evaluation Section, AMS. At least half of these were superior in appearance to the Porto Rico and Jersey Orange standard varieties and about equal in flavor ratings.

Tomato Breeding. Three hundred lines and varieties of tomatoes were tested for resistance to fusarium wilt. Highly resistant plants were fruited in the greenhouse.

Lines of tomatoes were evaluated for resistance to verticillium wilt and plants from 41 lines with high resistance were fruited in the greenhouse.

U. S. 357, a new, medium early wilt-resistant tomato was tested by the New Jersey Agricultural Experiment Station in several field trials on wilt-infested soil. As a result of these tests, growers with wilt-infested land are eager to test U. S. 357, which is a Valiant type, on a more extensive scale.

Tomato lines have been selected with tolerance to infection with tobacco mosaic virus. These mosaic-tolerant lines were grown in the field and

single-plant selections made from them. A group of 24 of these lines that have the best fruit characters and records of mosaic resistance are being intercrossed.

In developing methods of screening tomato seedlings for curly top resistance, improvements were made in methods of culturing leafhoppers. It was found that the use of artificial light to supplement the natural daylight during cloudy November weather reduced the amount of curly top infection, especially if florescent lights were used. The curly top resistant tomato variety Owyhee, released by the Idaho Station, was tested under Utah conditions. It was found to be inadequate in both horticultural type and curly top resistance in this area.

A tetraploid clone produced from Dr. C. M. Rick's Solanum-Lycopersicon hybrid by colchicine treatment gives some promise of breaking the barrier between Solanum and Lycopersicon and permitting the apparent curly top immunity of certain Solanum species to be incorporated into tomato. Crosses were attempted between various Solanum species and tomato without success. It is reported that Solanum pennelli crosses readily with tomato. Investigations of the disease resistance of this species and its compatibility with other species of Solanum and Lycopersicon species are in progress.

Greenhouse tests were made for resistance to Alternaria, Septoria, and Stemphylium as well as Fusarium (previously mentioned). Resistant materials were subsequently evaluated for field resistance to Cladosporium. Additional backcrosses were made for a study of linkage of the Septoria resistance gene.

Ascorbic acid (vitamin C) content in tomato lines ranged from 10.4 to 33.3 mg. per 100 gm. fresh weight. The average was 18.8 mg. per 100 gm. The vitamin C level was below standard in 65% of the new varieties under test. Inasmuch as some further reduction probably would occur both in fresh and in processed tomatoes before they were consumed, it is probable that breeders have become negligent of this important nutritional element.

Watermelon Breeding. Objectives are two: (1) the breeding of both large and small fruited varieties adapted to the Southeast, that are disease resistant and ship well, and (2) a genetic study of the characters of economic importance. Seed stocks of four promising small fruited (8-12 pound size) breeding lines were increased and two of these will receive extensive testing during the 1960 season. A number of grower trials have been arranged to help in the evaluation of this material.

Seventy-three single-fruit selections were made in our segregating tetraploid breeding stocks. Progress has been made toward the establishment of homozygous line embodying disease resistance, small seed size, increased fertility and high quality. It has been determined

from greenhouse inoculations that a triploid which carries only one gene (of three possible) for resistance to Colletotrichum lagenarium race 1 gives a resistant reaction. Also, no anthracnose has been observed on Rrr genotype plants in the field. It is concluded that while Rrr plants are not immune from infection, they do possess a very useful degree of resistance.

The sodium salt of alpha, beta-dichloroisobutyrate has shown promise as a male gametocide for use in the production of hybrid watermelons.

Plans: It is planned to continue work on most of the crops discussed in this section on essentially the present scale. One geneticist-plant breeder and two pathologists are to be employed within a year for initiating pea disease and breeding in the Pacific Northwest; also a pathologist to fit into the program for breeding for curly-top resistance in tomato. During the year there will be modest expansion of work on breeding of sweetpotatoes, onions, carrots, and the work of the Vegetable Breeding Laboratory at Charleston, South Carolina.

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B. Physiology and Nutrition

3. VEGETABLE PHYSIOLOGY AND NUTRITION

CR

Problem: Fundamental information is needed on a wide range of physiological and nutritional problems. Each vegetable crop has its own specific nutritional and environmental requirements and physiological processes. In seed physiology there is need of research to understand better the processes which affect longevity, dormancy, and germination, as well as development of improved methods of vegetable seed production (including growing and harvesting), and best use of seed on farms.

In the physiology of the growing vegetable crop there is a need to understand nutritional deficiencies and balance in their role to disease. There are many poorly understood relationships between environment and genetic inheritance of certain physiological-nutritional characters of great importance affecting flavor, texture, and ultimate utilization of the specific vegetable crop.

It is important to know the persistence of different toxic chemicals in soils and their effects on crops.

Program: These long-time basic studies are being conducted at Beltsville, Maryland and involve about $2\frac{1}{2}$ professional man years per year. Certain phases of the work are in cooperation (or coordinated) with the Mineral Nutrition Pioneering Research Laboratory of the Soil and Water Conservation Research Division; the Plant Physiology Pioneering Research Laboratory; other branches of the Crops Research Division; State Experiment Stations; and the Entomology Research Division.

Progress: Nutritional Studies of Melons (with emphasis on Crown Blight Control). (Coop. with Arizona Agricultural Experiment Station). In tests of the effects of organic materials on melon production and crown blight development, replicated plots were treated with (1) manure, (2) cyanamid, (3) Papago peas as a green manure, and (4) cropped continuously to muskmelons. There were no significant differences in yield. Treatment 3 showed a significantly lower percentage of leaves affected with crown blight. This treatment and treatment 1 produced vines with a significantly greater number of tips alive than in treatments 2 and 3.

Application of trace elements, magnesium, or high rates of nitrogen produced no significant differences in yields or incidence of crown blight in a trial in the Yuma area.

The effect of varying nitrogen applications on growth and composition of muskmelons was studied at Mesa. Soil previously cropped to grain was

treated with ammonium nitrate at 0 to 800 pounds of N per acre. Each increase in nitrogen increased plant size but not significantly. Yields increased with applications up to 400 pounds of N per acre but not with higher amounts. Highly significant differences in leaf nitrogen and phosphorus did not appear between treatments until fruit began to develop.

Mushroom Nutrition. For 2 years experiments have been made to determine how far mushrooms can efficiently translocate nutrients through the compost. Nutrients are transported with little loss of efficiency for at least 20 inches. The percentage of increased yields due to the additional compost in deeper beds is approximately the same for 30, 60, and 90 days of harvesting. This suggests that a complete "root system" has developed throughout the compost almost as soon as the first mushrooms appear on the beds.

Physiology of Onions. Onion seeds were germinated in sucrose solutions of different concentrations. Plants from the seeds that germinate under these conditions are being grown to maturity and the crop tested for total solids, starch, and other factors. To determine possible relationships between capacity of seed to germinate under high osmotic pressures and certain desirable economic properties. The plants will also be tested for drought and heat resistance and frost resistance.

Tests were made on a number of onion bulbs from a number of different breeding lines to determine the degree of correlation between pungency, as indicated by the refractive index of the juice and by the bromide-bromate titration methods. The results so far show a high positive correlation between the two methods.

Soil Microbiology. Experiments were conducted in the greenhouse and laboratory to determine the effects of green and mature plant materials (amendments), supplemental nitrogen, and combinations of amendments and nitrogen on behavior of Rhizoctonia solani in both the presence and the absence of a host.

In laboratory studies green manures added to soil suppressed competitive non-pathogenic activity of R. solani in the absence of a host. This suppression of the pathogen was in general unrelated to the soil reaction, the bacterial numbers in the rhizosphere of the bean host, or the rhizosphere/soil ratios of bacteria, streptomycetes, or fungi.

The dry (mature plants) amendments of corn, oats, and soybeans reduced the Rhizoctonia disease of bean and the competitive non-pathogenic activity of the pathogen in soil. Experiments are currently under way to determine whether the reduction in disease severity produced by some amendments is caused by physical or biological factors or both.

To study the nutritional requirements of the pea root rot organism (Aphanomyces euteiches), a synthetic medium (SM-1) was developed consisting of mineral salts, D-glucose, DL-glutamic acid, and

thioglycolic acid. Micronutrients were essential for growth, whereas vitamins were not. Oat plants either as a dry amendment or a green manure precrop reduced the pea root rot as did the fertilizer salts (NH_4NO_3 , Na_2SO_4 , NaNO_3).

Insecticide Metabolism by Microorganisms. A comprehensive series of experiments has been completed on action of organisms on a chlorinated insecticide. Two microorganisms, (1) a yeast (Schizosaccharomyces pombe) and (2) a bacterium (Pseudomonas beijerinckii) were used in these experiments. Both organisms require the vitamin-like substance, inositol for growth or pigment production. Special care was taken to avoid errors of earlier workers. Lindane while acting as a depressant did not competitively inhibit either growth or the more specific process of pigment production.

Seed Investigations. The germination response of certain seeds to red and far-red radiant energies was measured at optimum germination temperatures. The effect of temperature and period of imbibition in total darkness preceding the light treatment was also determined. Very little germination occurred in darkness at any temperature tested unless these seeds were partially after-ripened at 5° prior to placing them at the germination temperature.

The mode of action of gibberellin in the germination of light-requiring seeds of Lepidium virginicum and Grand Rapids lettuce, was studied. The response to four forms of gibberellin, optimum concentration, effects of buffering the acid and the potassium salt of GA, and the interaction with temperature and with the red, far-red pigment system, were determined. Gibberellins caused (1) light-requiring seeds to germinate in total darkness, (2) removed temperature blocks to germination and, (3) prevented the onset of dormancy imposed by high temperature.

Plans: New studies of the biochemistry of germination processes are being started. The germination changes of ribonucleic acid and several nucleotides will be investigated. Further studies will be made on the role of light in the control of germination, and the interaction between light, temperature, and chemicals. The problem of relationship between seed and seedling vigor will be studied.

Studies will continue to identify, nature, and metabolic products of chlorinated hydrocarbons. In general, research on physiological problems will continue for the coming year on essentially the same scale as at present.

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C. Cultural Practices

4. VEGETABLE CULTURE

CR

Problem: Despite the large amount of cultural research on vegetable crops conducted in the past, there is need for continuing studies to meet the ever-changing demands of the vegetable industry. New harvesting techniques, new processing methods, changed insect and disease control, and the development of hybrids and other new plant types (particularly in tomatoes) are but a few of the changes which require adjustments and improvements in present cultural practices.

To provide a sound scientific basis for a developing seed industry, it is essential to learn the ways in which environmental conditions during seed production, including cultural practices, can influence seed yield and seed quality.

Program: There is no large-scale program of research in vegetable culture per se because so many cultural practices are tied to local conditions. Cultural studies are, however, major parts of investigations on vegetable seeds and on mushrooms, involving about 2 professional man-years per year.

Vegetable seed production research, a long-range continuing program, involves field production studies at Logan, Utah, and Kimberly, Idaho, and germination evaluation studies at Beltsville. Certain phases are in cooperation with the Utah Agricultural Experiment Station, the Entomology Research Division of the Agricultural Research Service, and the Idaho Agricultural Experiment Station.

Mushroom cultural studies are conducted at Beltsville and in cooperation with growers in the southeastern Pennsylvania mushroom-growing district.

Progress: Vegetable Seed Production. Studies on the effect of insect pollination on carrot seed yield and quality show that at low pollination levels there is a reduction not only in yield but also in seed viability and a large number of abnormally large or small seeds are produced. Thus, an adequate supply of insect pollinators is required not only to obtain high yields, but also to produce a high quality seed crop.

Research on the effect of irrigation treatments on snap bean seed production shows that high moisture levels produce the highest yields of seeds, and that these seeds tend to be slightly larger than those grown under low moisture levels. Seeds from high moisture levels, however, tend to be slightly more susceptible to mechanical injury than those grown at low moisture.

Sweetpotato sprouting tests. Timely and abundant production of strong sprouts is essential for commercial acceptance of new varieties. Sprouting characteristics of advanced selections were tested at Meridian and at Clemson, S. C. B-6716 and HM-288 were early and prolific sprouters, whereas B-6652, HM-434, and HM-475 were relatively poor plant producers.

Melon culture as related to Crown Blight. Experiments were conducted on the relation of cultural practices, use and type of fertilizers, and irrigation to development of crown blight and plant growth and yield. At Yuma, Arizona replicated plantings were made at approximately 14-day intervals from January 13 to March 10, 1959. One-half of each planting received a pre-planting treatment with an insecticide (Thimet). There were no significant differences in yield of marketable fruit except in the second planting where the stands were reduced and there was poor early season growth. Virus disease incidence increased sharply after May 10 when temperatures first became high and aphids were numerous. Virus infection alone did not seem to account for early leaf decline characteristic of crown blight.

Vines in replicated plots were (1) "turned" in normal fashion, (2) the hands disinfected before "turning" each plant, (3) left "untreated" and subject to normal injury from furrow cultivation, (4) rough handled, (5) not turned, but runner tips pruned with a knife disinfected before each cut, and (6) pruned without disinfecting the knife. No differences in crown blight incidence were associated with any treatment. Treatment 2 produced significantly more marketable melons than Nos. 3, 4, 5, or 6. Treatment 1 produced significantly more marketable fruit than Nos. 4 and 6 but not more than 2, 3, or 5.

Continued irrigation experiments at Mesa again included plots held at moisture stresses classed as "very wet," "wet," "dry," and "very dry." No differences in yield or distribution of sizes of marketable fruits from "wet" and "dry" plots were apparent. "Dry" plots were most efficient in use of water in terms of production although "very wet" plots were given no water after fruits were developing yields decreased sharply. Yields from "very dry" plots increased greatly when water was applied after a 2-week period

of severe drought symptoms. No consistent or significant relation between irrigation and crown blight was noted.

Use of Plastic in Melon Culture. One acre of melons was planted under black plastic mulch. The effect on speed of germination, total stand, moisture control and weed control was highly favorable, but marketable yields were not improved and quality was affected adversely. Apparently the black plastic has a favorable effect early in the season when temperatures are below optimum but becomes disadvantageous later in the season when temperatures are above optimum.

Mushroom Culture. The relative humidity of the air in a mushroom house and the rate of air movement over the beds are important factors in determining the quality of the mushrooms. To study these factors, experiments were made in special "wind tunnels" operating in rooms with controlled relative humidities. More than 90 percent relative humidity is undesirable since the mushrooms are likely to be "wet skinned" and predisposed to spot diseases. Low humidities also are undesirable since they cause too rapid drying of the mushroom surface which leads to "cracking," "scaling," and "tanning."

Very satisfactory mushroom quality was obtained with the temperature maintained at approximately 60° F., the relative humidity between 80 and 85%, and air velocities between 1/2 and 1 foot per second.

Tomato Culture. Yield trials were grown on trellises. Marketable yields apparently were increased about 50% over ground beds, and the determinate vine types surprisingly responded more favorably than the indeterminate vine types. The increase in yield was partly a result of reduced loss due to fruit rot and partly due to an extension of the bearing season. No data were obtained on relative costs, but trellis culture is of course the more costly.

Plans: Work will be continued to determine the effect of irrigation practices on the yield and germinability of pea seeds, and the effect on seed quality of various harvesting and field curing procedures.

Studies will be continued on the effect of irrigation practices on yield and susceptibility to mechanical injury of snap bean seed; on effect of insect pollination on onion seed production and seed quality; and the effect of herbicides on the control of weeds in direct seeded onions.

Cultural studies will be expanded in the coming year, especially for the South. Cooperative programs remain to be developed.

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5. SOIL AND WATER MANAGEMENT AND CONSERVATION

SWC

Problem: Moisture conservation is a highly important problem in all vegetable growing areas and farmers are concerned with devising methods of irrigation, prevention of soil and water losses through erosion, and developing soil management and crop rotation systems under which vegetables can be grown economically.

Program: A continuing program to study soil and water management practices which make for more efficient use of water supplies and to increase basic and applied knowledge relating to the soil-water-plant system, including fertility needs. In studies where vegetables are used as tools to gain these objectives about eight professional Federal man-years annually are involved.

Progress: Knowledge of water consumption by plants under various salt treatments is of basic importance. Experiments show that the consumption

of water per unit weight of leaf tissue by kidney beans increase under increasing osmotic pressures of the culture solution. There is evidence to believe that one of the aspects of the problem of salinity is the less efficient use of water for metabolic purposes, as compared with nonsaline growing conditions. It appears that the mechanism responsible for opening and closing the stomata of the leaves is salt-sensitive. Other work on water uptake by kidney bean plants indicated that, under the influence of daylight, when the stomata were fully opened, the water consumption was many times greater than during an equal period of darkness, when only cuticular transpiration takes place.

During 1959 studies were continued with vegetable crop irrigation in New Jersey. There was a 50 percent increase in cabbage yield from irrigation. This resulted largely from increased weight and size of heads although there was some tendency toward increase in number of marketable heads. Rotation with sod or cover crops, as in previous years, depressed yields. Rainfall was adequate during the tasseling period of sweet corn thereby eliminating the need for irrigation in 1959. Cover crops had no effect on yield either. Irrigation increased the number of marketable cantaloupe melons and total yield in 1959, but cover crops and sod based rotations had no effect. Both yield and quality of snap beans were increased by irrigation while fall turnips and spinach were unaffected by irrigation.

Bean plants were grown on soils which had been adjusted to four levels of calcium saturation and then irrigated with brackish water. The rate of evapotranspiration decreased linearly with increased salinity but liming the soil had no effect. Yield was also decreased with increasing salinity but liming increased bean yields. Apparently the chemical composition of the soil saturation extract controlled plant composition rather than the exchangeable cations.

A greenhouse experiment was carried out to compare the effects of gradual soil salinization with salinization in one application, on the growth of beans. Diluted sea water added to soil in multiple irrigations was compared with the addition of a total equivalent amount of salt at the time of the last irrigation. Higher yields of both tops and pods were obtained where salinization was accomplished in one application. Evapotranspiration was greater with multiple applications. The higher equilibrium salt concentration of the saturation extract following gradual salinization was reflected in chemical composition of the plants.

The presence of salinity generally decreased the transpiration rate for all crops, the reduction tending to be greater with higher salinity. The bell pepper afforded a clearcut example of a decrease in transpiration rate due to salinity. For this crop, each level of salinity reduced transpiration rate below that of the preceding lower saline treatment in a step-wise manner. Since this experiment was conducted during periods of rather

low evaporation rate, it is planned to repeat the experiment under summer conditions.

The loss of calcium from an irrigation water can lead to serious problems. These may appear as nutritional difficulties in the crops or as chemical and physical problems in the soil. The most important reaction by which calcium is lost from the water involves the precipitation of the calcium as calcium carbonate. As a result of this loss, there is an increase in the ratio of sodium to calcium in the water and a corresponding increase in the hazard connected with the use of the water for irrigation. Research is in progress on this precipitation reaction having as an objective the development of a procedure whereby the hazards can be foreseen and possibly eliminated.

When evaporation from the soil surface was controlled by the use of black polyethylene film, there was enough moisture in the soil at field capacity to produce a crop of cantaloupes in New Jersey. Yields were as good or better than where the melons were clean cultivated. Soil fertility measurements indicated less nutrient loss by leaching under the plastic.

Plans: Basic studies will be continued to get more information on the soil-water-plant relationship as it affects vegetable and other crop growth. More specifically some of the studies will include irrigation water management and requirements of irrigated crop interrelationships.

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D. Weed Control

6. WEED CONTROL INVESTIGATIONS

CR

Problem: The supply of hand labor for vegetable production is critically low, mechanical methods of weed control are inadequate, and therefore, new and improved methods of weed control are urgently needed to reduce production costs and facilitate the mechanization of this industry.

Program: This is a continuing long-term program of basic and applied research on the chemical, physiological, climatological, soil, cultural, and varietal problems associated with the development of practical methods of weed control, conducted at Beltsville, Maryland, and in cooperation with the State Experiment Stations in Arizona, New Jersey, Texas, Washington, and Wyoming. It involves approximately three professional Federal man-years annually.

Progress: Asparagus. Studies were continued in Washington on the control of weeds in asparagus and it was found that spring applications of monuron at 4 pounds or duron at 3 to 4 pounds per acre accompanied by shallow rotovation gave improved weed control without causing injury to the crop.

Beans. Serious annual broadleaved weed and weed grass problems exist in field beans. Research in Wyoming showed that pre-emergence applications of EPTC at 3 to 4 or CDEC at 6 to 8 pounds per acre effectively controlled these weeds.

Work on these weed problems in field beans in Washington revealed that shallow incorporation of pre-emergence applications of EPTC at 3 to 6 pounds per acre improved the effectiveness of pre-emergence applications of this herbicide.

Studies of the tolerance of beans and certain other legume vegetables to herbicides were conducted at Beltsville, Maryland. Certain of these crops had a tolerance to amiben, an effective new herbicide. In work with amiben, an effective new herbicide, 12 bean and other legume crops including Clark Bush lima beans, Henderson Bush lima beans, Fordhook lima beans, Broad beans, Big Brown Purple Hull cowpeas, Cream Crowder cowpeas, Top Crop snapbeans, Cherokee Wax beans, Kentucky Wonder Pole beans, Pinto beans, Chinese Salad beans, and edible soybeans were evaluated for their tolerance to pre- and post-emergence applications. Lima beans and edible soybeans were tolerant of pre-emergence applications of amiben at 5 pounds per acre, an effective herbicidal rate of application.

Cantaloupes and Cucumbers. Broadleaved weeds and weed grasses are an especially serious problem in vine crops because they cannot be cultivated in the middle and latter stages of growth. Studies in

Arizona have shown that pre-emergence applications of NPA at 9 pounds per acre are effective in controlling many of these weeds but this treatment does not control puncture vine, one of the most serious weed problems in these crops. The importance of the control of this weed in vine crops indicates the need for continued intensive evaluation of new herbicides in this research.

Carrots. The Stoddard solvent herbicidal oils have been used extensively in commercial carrot production. This herbicide, though effective in controlling many annual broadleaved weeds and weed grasses, does not control certain important weeds such as ragweed, Galensoga, and others.

Research in Arizona has shown that pre-emergence applications of 3-(3,4-dichlorophenyl)-1-isopropyl-1-(2-propynyl)urea at 2 to 5 pounds per acre and post-emergence applications of N-(3,4-dichlorophenyl)-2-methylpentanamide at 3 pounds per acre may hold promise for general control of weeds in carrots in that area.

Intensive studies on the evaluation of new herbicides for the control of weeds in furrow-irrigated carrots have been conducted in Texas. Several new herbicides including EPTC, CDEC, CIPC, and EPTC plus CDEC were studied as treatments on hot, air-dry soils 2 weeks before planting and at planting time where furrow-irrigation was used to grow the crop. Applications of CDEC at 6 pounds per acre was the only effective treatment in this study. Post-emergence treatments of N-(3,4-dichlorophenyl)-2-methylpentanamide, granular carbamates and Stoddard solvent either were ineffective in controlling all of the weeds or caused injury to the crop.

Preliminary investigations on the tolerance of carrots to new herbicides were conducted at Beltsville, Maryland. Carrots were found to be tolerant of pre- and post-emergence spray applications of amiben, propyl ethyl-n-butylthiolcarbamate, dimethyl ester of 2,3,5,6-tetrachloroterephthalic acid, and 3-(3,4-dichlorophenyl)-1-isopropyl-1-(2-propynyl)-urea at rates that effectively controlled weeds under Maryland conditions.

Cole Crops, Greens, and Salad Crops. The control of weeds in cole, greens, and salad crops is difficult and expensive because high rates of seeding are used and many of these crops grow semi-prostrate or prostrate on the soil. Mechanical methods of control are inadequate or non-existent. Commercial production of these crops is widely distributed geographically involving many variations in climate, soils, rotations, and cultural methods. These variations in environment have a profound effect on the effectiveness of herbicides. Research is therefore necessary to determine the specific conditions necessary for the effective use of herbicides on these crops in the several large geographical areas.

The high temperatures, high light intensities, high salt content of many of the soils, and the use of furrow-irrigation in Texas and other southwestern and western States determine the herbicides and methods of application that may be used effectively in these areas. Intensive studies are being conducted in Texas on new herbicides and the effect of environment and cultural methods on their performance and persistence. It has been found that pre-emergence applications of CDEC and CDEC plus diuron are effective in controlling weeds in spinach without injuring the crop. Studies on cabbage at the same location have shown that pre-emergence applications of CDEC controlled annual weeds without reducing yield or quality of the crop.

Preliminary studies at Beltsville, Maryland have shown that a number of cole, greens, and salad tops are tolerant to herbicidally effective pre-emergence applications of ethyl ethyl-n-butylthiolcarbamate, dimethyl ester of 2,3,5,6-tetrachloroterephthalic acid, and N-(3,4-dichlorophenyl)-2-methylpentanamide and to post-emergence applications of propyl ethyl-n-butylthiolcarbamate and the dimethyl ester of 2,3,5,6-tetrachlorotere-phthalic acid.

Onions. A number of new herbicides were evaluated for the control of serious weed problems in onions in Arizona. None of the new chemicals was found superior to sulfuric acid, though certain weeds in onions in that area are not controlled with this chemical. The evaluation of new herbicides will continue in an effort to discover more effective herbicides for use on onions.

Sweet Corn. DNBP and 2,4-D have been used to some extent in the commercial production of sweet corn. These herbicides do not adequately control a number of the weeds and certain varieties of sweet corn are injured by 2,4-D. Improved herbicides are therefore urgently needed.

Evaluation of new herbicides at Beltsville, Maryland has shown that sweet corn is tolerant of herbicidally effective pre-emergence applications of propyl ethyl-n-butylthiolcarbamate, dimethyl ester of 2,3,5,6-tetrachloroterephthalic acid, 3-(3,4-dichlorophenyl)-1-(2-propynyl)urea, and N-(3,4-dichlorophenyl)methacrylamide. These preliminary data, and the continuing research program on the evaluation of new chemicals will provide the basis for improved methods of weed control in sweet corn.

Sweetpotatoes. CIPC and NPA are being used for the control of weeds in sweetpotatoes on a limited basis, commercially. Though helpful in controlling a number of weeds, these herbicides do not provide effective general weed control and are quite sensitive to soil moisture level at the time of treatment.

In a search for improved methods of weed control for sweetpotatoes, a preliminary evaluation of several new herbicides was conducted on this

crop at Beltsville, Maryland. It was found that sweetpotatoes were tolerant of herbicidally effective post-transplanting and lay-by applications of the dimethyl ester of 2,3,5,6-tetrachloroterephthalic acid.

Tomatoes. Weeds that emerge and grow after the last cultivation of tomatoes are a major problem in the production of this crop.

Research conducted on furrow-irrigated tomatoes in Texas showed that EPTC controlled weeds effectively but reduced yields. Research is continuing in an effort to find suitable herbicides to solve the problem under these cultural and climatic conditions.

Investigations at Beltsville, Maryland have shown that a granular formulation of EPTC cultivated in at lay-by at the rate of 4 pounds per acre controlled annual grasses and broadleaved weeds in non-irrigated tomatoes without injury to the crop. These results indicate progress but the weed problem in tomatoes has not been solved. Research is continuing using new herbicide chemicals and methods of application accompanied by basic studies on the effect of environmental conditions and cultural techniques on the effectiveness of herbicides.

Plans: Basic and applied research on new herbicides, combinations of herbicides, methods of application, mechanical methods, cultural practices, and various combinations of these methods will be continued to develop more efficient methods of weed control for vegetable crops. Basic studies will include research on the physiological responses of these crops to herbicides and the effect of climate, soil composition, and cultural methods on the performance and persistence of herbicides in and on the crops and associated soils. Studies will be conducted on the post-harvest physiology, quality, and herbicide residue content of treated crops wherever possible in this program.

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E. Disease and Nematode Control

7. DISEASE CONTROL

CR

Problem: Vegetable crop diseases caused by fungi, viruses, nematodes, and physiological factors annually result in hundreds of millions of dollars of damage or loss in yield, quality, and efficiency of production of vegetables. Many diseases are new and poorly understood. Others have been known for many years and still more research to bring them under control.

Program: A continuing long-term program of basic and applied research involving about 12 Federal professional man-years annually at Beltsville, Maryland; Weslaco, Texas; Twin Falls, Idaho; Prosser, Washington; E. Lansing, Michigan; La Jolla, California; Madison, Wisconsin; in cooperation with the respective States, regional and private industry groups.

Progress: Bean and Pea Diseases. In continued studies in microbiological control of bean root rot in Washington significant reductions in infection were again obtained with seed furrow applications of finely ground organic matter at 50 lbs. per acre. In 2 tests in commercial fields the best treatments were alfalfa hay or barley straw inoculated with a nonpathogenic species of Fusarium. The same materials applied to the seed with Karo syrup or molasses as stickers were ineffective. Other stickers, organic matter, and fungicide combinations gave varying results.

An efficient seedling method for testing Fusarium (attacking bean) survival and density in soil, pathogenicity of cultures, and disease resistance in plants has been developed.

Cabbage diseases. At Madison, Wisconsin, a new physiologic race of the cabbage clubroot organism has been found in the vegetable area of the southeastern part of the State, and is now being studied and increased in a pure line form in the greenhouse on differential test plants.

Cucumber diseases in the East: Work was continued on the longevity of cucumber mosaic virus in dehydrated leaf tissue which, so far, have survived 24 months storage at 40° C.

Melon Diseases (with emphasis on relationship of virus diseases to crown blight. At Yuma, greenhouse isolations and identifications of viruses affecting muskmelons in the field showed that watermelon mosaic (WMV) and cucumber mosaic (CMV) were the most prevalent and WMV by far the most common. The character and severity of the injury produced by these viruses has not been fully determined, but work is continuing.

At Tucson, Arizona a number of strains of cucumber mosaic virus, and a yellow ringspot virus thought to be related to tobacco mosaic virus, were studied in the greenhouse. The symptoms produced by CMV and the yellow ringspot virus, when tested on muskmelons either singly or in combination, showed some resemblance to certain types of leaf injury that make up the complex of crown blight symptoms. Since the ringspot virus was isolated from tomato, it is suggested that muskmelons should not be planted close to tomatoes until further information on this virus is available.

Pepper diseases. At Beltsville, Maryland studies were conducted on the behavior of various strains of X. vesicatoria on pepper. Strains mildly pathogenic on pepper and strongly pathogenic on tomato have not shown increased pathogenicity on pepper after 4 passages through pepper.

Spinach diseases. The screening for resistance to blue mold has been improved with the discovery that sharp-frozen (-10° F.) and vacuum-dried conidia of blue mold with subsequent storage at 0° F. were viable after 12 and 10 months, respectively.

Sweetpotato Diseases. Seedlings were tested for resistance to black rot; about 16 percent of 130-odd tested were found to have some resistance.

Aphid transmission studies of sweetpotato viruses, in cooperation with the Entomology Research Division, were continued and expanded. In field and greenhouse experiments, aphids were found to transmit the foliage spot complex made up of internal cork and leaf spot viruses.

The abutilon whitefly, *Trioleurodes abutilonea* was used in greenhouse and field transmission studies of yellow dwarf. By breaking off the weed host in late August, the insects were induced to leave the dying weed to feed and breed on the sweetpotato. When this technique was used, 20 percent natural field transmission of yellow dwarf occurred, compared to less than 5 percent when the weed was left undisturbed the year before.

Tobacco ring spot virus was isolated and identified from the sweetpotato variety Acadian received from Indiana, and in the variety Triumph grown at Beltsville. This is the first report of tobacco ring spot virus in sweetpotato.

Thermal inactivation studies were run on several isolates of sweetpotato viruses. Preliminary work indicates that thermal inactivation may be a useful basis for separation of isolates and strains.

Tomato Diseases. A strain of *Xanthomonas vesicatoria* highly pathogenic on pepper but only mildly damaging to tomato has been passed through tomato plants several times and cultures from these plants tested on tomato and pepper. So far there is little evidence of alteration of its behavior on tomato after passages through this host.

Microbiological Studies. Studies have been continued to characterize certain soilborne fungi and to discover facts and principles relating to the microecology of the soil that may eventually lead to practical methods of control of root rots and related plant diseases.

Among the nematode-capturing fungi that have come under observations during the past year, three appear to represent new species. A fourth fungus of similar biological character would seem referable to a species described in England, though observed there only once. The 4 species are being prepared for publication.

Plans: Disease investigations on the several crops and disease-causing agents will be continued for the present year along similar lines and at a level almost similar to that of last year. Two pathologists are to be employed within a year for initiating pea disease and breeding in the Pacific Northwest; also a pathologist to fit into the program for breeding for curly-top resistance in tomatoes. Modest expansion of bean disease studies is planned at Beltsville and other locations.

Publications: Natural Transmission of Sweetpotato Feathery Mottle Virus by the Whitefly, *Trialeurodes abutilonea*, conditioned by Climate. E. M. Hildebrand. (abstract) *Phytopath.* 49:524. July 1959.

Sweetpotato Ringspot Virus associated with Internal Cork Virus. E. M. Hildebrand. (abstract) *Phytopath.* 49:524. July 1959.

Preliminary Observations on the Internal Cork Virus Complex in the Sweetpotato. E. M. Hildebrand. *Pl. Disease Reporter.* 43: 1070-1072. Oct. 15, 1959.

Sweetpotato Diseases. E. M. Hildebrand and Harold D. Cook. *USDA Farmers Bul. No. 1059:1-28.* (Revised Nov. 1959).

Vein necrosis, a virus disease of bean. (Abstr.) W. J. Zaumeyer. *Phytopath.* 49:526. 1959.

New tobacco streak virus from symptomless alfalfa infectious to beans. (Abstr.) W. J. Zaumeyer. *Phytopath.* 49:555. 1959.

Unusual reaction of two snap bean varieties to two strains of common bean mosaic virus. L. L. Dean and V. E. Wilson et al. *Pl. Disease Reporter.* 43:131-132. 1959.

A recently discovered virus-induced streak disease of peas. W. J. Zaumeyer and Graciano Patino. *Plant Disease Reprtr.* 43: 698-704. 1959

A new strain of common bean mosaic in Idaho. L. L. Dean and V. E. Wilson. *Plant Disease Reprtr.* 43:1108-1110. 1959.

A Strain of Cucumber Virus 1 Infectious to Blight-Resistant Spinach. S. P. Doolittle and R. E. Webb. *Phytopath.* 50:7-9. 1960.

Strains of *Xanthomonas vesicatoria* (Doidge) Dowson differing in virulence on tomato and pepper. S. P. Doolittle and D. F. Crossan. *Plant Disease Reprtr.* 43(11): 1153. 1959.

Insects and diseases of vegetables in the home garden. L. B. Reed and S. P. Doolittle. *USDA Home and Garden Bul. No. 46.* 1959.

A strain of cucumber mosaic virus 1 infectious to blight-resistant spinach. S. P. Doolittle and R. E. Webb. *Phytopathology* 50(1):7-9. 1960.

Two root-rot fungi closely related to *Pythium ultimum*. Charles Drechsler. *Sydowia.* 14. 1960.

A Pythium causing stem rot of tobacco in Nicaragua and Indonesia. Charles Drechsler. *Sydowia.* 14. 1960.

Conidial propulsion in Meristacrum asterospermum. Charles Drechsler. Sydowia. 14. 1960.

Two species of Conidiobolus found in plant detritus. Charles Drechsler. American Journal of Botany 47:368-377. May 1960.

Evaluation of various media and antimicrobial agents for isolation of soil fungi. G. C. Papavizas and C. B. Davey. Soil Science 88: 112-117. 1959.

Effect of organic soil amendments on the Rhizoctonia disease of snap beans. C. B. Davey and G. C. Papavizas. Agronomy Journal 51:493-496. 1959.

Investigations on the control of the Rhizoctonia disease of snap beans by green organic soil amendments. G. C. Papavizas and C. B. Davey. Phytopathology 49: 525. 1959.

Effect of mature plant materials and nitrogen on Rhizoctonia solani in soil. C. B. Davey and G. C. Papavizas. Phytopathology 49: 537. 1959.

Extent and nature of the rhizosphere of Lupinus. G. C. Papavizas and C. B. Davey. Proc. Intern. Botan. Congr. 9th Congr. Montreal 2: 293. 1959.

Biological control of soil-borne plant pathogens. C. B. Davey and G. C. Papavizas. Proc. 6th Pacific Coast Res. Conf. on Soil Fungi. p. 21-24. 1959.

8. PLANT DISEASE FORECASTING

CR

Problem: Tomato late blight, and downy mildew of the curcurbit crops and lima bean fluctuate greatly in their destructiveness from year to year and from one location to another. Effective chemical control measures are available but are economically feasible only if they are applied at the proper time. They are too expensive to be applied routinely if the disease is light, but yield great returns when the disease becomes epidemic. Accurate experimental seasonal forecasts based upon the epidemiology (study of factors affecting initiation, spread, and severity) are needed to help provide economical control for these diseases.

Program: This continuing long-range program of applied and basic research is conducted at Ames, Iowa; Raleigh, North Carolina; and Newark, Delaware; in cooperation with the thirty-eight State Experiment Stations in the Eastern half of the country. It involves about 2 professional Federal man-years annually.

Progress: In the north-central region, laboratory and field research on the factors involved in the development of tomato late blight (Phytophthora infestans) was conducted. The laboratory work was planned primarily to obtain information on the effect of temperature on the initiation and duration of sporulation, germination, and infection, the critical stages in the life history of the fungus. No sporulation took place on lesions on detached leaves held at 45° F. At 50° the minimum time for sporulation was 8 hours; at 55° it was 6 hours.

Exposure to the temperature range 44°- 63° resulted in some sporulation after 12 hours. Low percentages of sporangia germinated after exposure to temperatures ranging from 70° to 83° through 24 hours. Some germination occurred after 6 hours exposure to temperatures fluctuating between 69° and 72°, and some after 6 hours at 71°. Comparison of results obtained from experimental prediction of blight-favorable weather on the temperature-90 percent relative humidity basis with results from methods depending on temperature and rainfall records showed that the former procedure is definitely better suited to the conditions of the north-central region.

In the northeastern region downy mildew of lima bean is forecast on an experimental basis in the principal green lima bean areas in Long Island, New Jersey, Delaware, Maryland, and Pennsylvania. The method used as a standard for comparison depends on rainfall and temperature records for delimiting downy mildew weather. In New Jersey and Delaware three new methods were tried experimentally in 1959. Downy mildew favorable weather was defined on the basis of temperature and 90 percent relative humidity in one method, of temperature and 75 percent relative humidity in another, and of temperature and dew deposition in the third. Dependability of the three methods was about equal. None was superior to the temperature-rainfall method. The maximum temperature on the day following a potential infection period was important. When 85° F. was considered to be limiting temperature, actual incidence and spread of downy mildew agreed very well with the calculated infection periods, but when higher temperatures, 90° or 95°, were used as the limit many of the potential infection periods occurred late in the season when the disease was inactive.

In the southeastern region investigations on the epidemiology of cucurbit downy mildew were continued. The only known means by which the fungus, Pseudoperonospora cubensis, perpetuates itself is by overwintering on cucurbit hosts in frost-free areas of southern Florida. As the season progresses the disease moves northward by means of airborne spores. In 1959 downy mildew was not observed in the southern part of North Carolina until June 27, and in the northern pickle-growing area until August 3, too late for control practices to be recommended.

Plans: Investigations will be continued to develop more accurate criteria for determining environmental conditions which are conducive to late blight epidemics. "Late blight gardens," tomato plots will be located in isolated and strategic geographical regions, and used throughout the season as a means for comparing the initiation, spread, and severity of late blight in these inoculated experimental gardens with the same in growers' fields.

Cooperative work with the Weather Bureau will be expanded in all regions where downy mildew epidemiological studies are being made in the hope of developing more extensive and longer range experimental disease forecasts.

Attempts to germinate the oospores of *Phytophthora phaseoli* will be made, utilizing a variety of cultural media and through the use of chemical stimulants. Since the downy mildew fungus of cucurbits cannot be grown on artificial media attempts will be made to grow this fungus on cucumber callus tissue and enlarged cotyledons of cucumber grown on culture media and inoculated during the summer with spore suspensions of *Pseudoperonospora cubensis* from naturally infected cucumber leaves.

Publications: New Aids for Forecasting Downy Mildew of Lima Bean. R. A. Hyre, *Phytopathology*. 1960.

9. NEMATOLOGY INVESTIGATIONS

CR

Problem: Vegetables in all parts of the country are subject to attack by a number of species of plant-parasitic nematodes which cause direct damage and, in association with bacteria and fungi, are the cause of various kinds of root rots. Expanded research on the relationship of nematodes, vegetables, fungi and bacteria should result in improved methods for controlling this damage by the use of chemicals, cultural practices and nematode resistant varieties.

Program: A continuing program of basic and applied research is conducted at Charleston, South Carolina; Tifton, Georgia; Tempe, Arizona; and Weslaco, Texas, in cooperation with the experiment stations of the respective States. About three professional Federal man-years are involved annually.

Progress: Nematode problems in the vicinity of Charleston, South Carolina. The effort of the Nematology Field Station established at Charleston, South Carolina on July 1, 1959 has been devoted to a preliminary survey of the nematodes attacking vegetables in that vicinity. This has shown that stubby-root nematodes and spiral nematodes are the predominant forms, occurring in large numbers in all fields and attacking practically all of the vegetable crops grown there. In addition, root-knot nematodes, dagger nematodes, root-lesion nematodes, ring nematodes and stunt nematodes are often found. Sting nematodes are abundant in certain fields, particularly in sandy soils.

The use of nematocides containing methyl bromide in vegetable production. Experiments were conducted at Tifton, Georgia, for the purpose of comparing vaporized methyl bromide with liquid formulations of methyl bromide in an inert carrier, a mixture of methyl bromide, chloropicrin and propargyl bromide, and DBCP, sold as Nemagon and Fumazone. The liquid formulations of methyl bromide were applied with a newly developed machine which injects the chemical and covers the soil surface with a thin sheet of plastic. For tomato transplants grown from seed, the nematocides containing methyl bromide gave very good nematode control and also excellent control of weed seeds, reducing total weeds about 90%. Tomato production in plots treated with these materials average about 12,300 lbs. per acre compared with 4,200 lbs. for the untreated controls and an average of about 6,800 lbs. for the plots treated with DBCP.

Increases in vegetable yields with nematocides in Georgia. In a series of experiments with nematocides containing dichloropropene, ethylene dibromide or DBCP yields of vegetables were increased in comparison with controls by the following percentages: cantaloupes, 72%; lima beans, 41%; bush beans, 138%; okra, 230%; squash, 84%; peppers, 12%; sweet corn, 22%. In another experiment in a field where sting nematodes were present, yield of marketable sweet corn was increased 136% over the controls.

Increased yield of root-knot nematode resistant lima bean in Georgia. In a Georgia field lightly infested with root-knot nematodes, the Nema-green variety of lima bean yielded 3,013 lbs. per acre on soil not treated with a nematocide as compared with yields of 2,958 lbs. per acre for the non-resistant Thorogreen variety on soil treated with a nematocide and only 2,270 lbs. per acre for Thorogreen on untreated soil. That is, yield of the root knot resistant variety without a nematocide was equal to that of the non-resistant variety with a nematocide, and 41% higher than the non-resistant variety without a nematocide. This illustrates the potential value of nematode-resistant vegetable varieties.

Plans: The work at Charleston will be continued at its present level with the objective of developing information needed by plant breeders for developing nematode resistant varieties of vegetables. The work at Tifton will be continued at about its present level with the objective of developing improved safe methods of using nematocides for control of nematodes on vegetables.

Publications: Plant Nematodes and soil management practices. J. M. Good. Soil Conservation. 25(11):249-251, 259. June, 1960.

Evaluation of application methods for applying 1,2-dibromo-3-chloropropane for control of root knot. J. M. Good and A. E. Steele. Plant Disease Reporter 43:1099-1102. Oct. 1959.

Effect of soil fumigation on prevalence of southern blight in tomatoes. H. W. Rankin and J. M. Good. Plant Disease Reporter. 42:444-445. Apr. 1959.

F. Insect Control

10. INSECT VECTORS OF VEGETABLE DISEASES

ENT

Problem: To expedite the solution of plant disease problems by determining the insects responsible for carrying diseases to such plants as melons, peas, and sweetpotatoes, and developing methods of preventing them from spreading the viruses or other disease-causing agents. The interactions of insects and certain viruses are known, but a large number of possible important disease-insect relationships remain to be explored. Acquisition of new knowledge will contribute greatly to the development of means of avoiding or controlling the spread and severity of many economically significant disorders of plants.

Program: A long, continuing program of basic research by a team of entomologists and pathologists (of Crops Research Division) on the fundamental nature of the role played by insects in the spread of diseases of vegetables, supplemented by applied research on the control of the insect vectors. This work was conducted by field stations in Maryland, Arizona, Colorado, Idaho, and Washington, in cooperation with the respective experiment stations and involving about three professional Federal man-years annually, exclusive of cooperation by the pathologists.

Progress: Relative to the "crown blight" problem, the effect of two insect borne virus diseases on cantaloups was studied in experimental plots at Mesa, Arizona in 1960. These diseases were curly top, transmitted by the beet leafhopper, and cucumber mosaic, transmitted by aphids, primarily the green peach aphid. Plants were inoculated with each of these viruses alone and in combination when they were in the late 6-leaf stage. At this stage cantaloup plants are partially resistant to curly top, thus complete destruction by this disease was avoided. These studies showed a 40-percent reduction in vine growth from cucumber mosaic but no growth reduction from curly top inoculations on plants of this size. Yield of marketable melons was, however, reduced 32 percent by curly top alone, 40 percent by cucumbet mosaic, and 68 percent when plants were inoculated with both viruses.

Small field plot experiments in Arizona with artificial infestations of curly top-infective beet leafhoppers on pretreated cantaloup plants showed that applications of phorate granules under the seed or phorate foliage sprays on 2-leaf plants gave protection against leafhoppers caged on the plants before they passed the 4-leaf stage. Treated plants were larger than untreated plants. Those treated with

granules under the seed produced 24 percent more melons than untreated plants. Foliage sprays 2 days before infestations in the 2- to 4-leaf stage resulted in a 33 percent increase in marketable melons over untreated plots infested in the same stage of plant development. None of the treatments were effective in protecting the plants from leafhoppers allowed to feed only on plants past the 4-leaf stage. In large scale field tests, curly top incidence was too low to show differences caused by treatments similar to those in the small plots. When plants had runners 1 foot long, no phorate could be detected in the new leaves and none was found in the rind or flesh of the fruit.

In vector tests of 58 different species of leafhoppers during the past two years in Idaho, none but the beet leafhopper transmitted the virus of curly-top disease. Ecological studies continued to indicate that the beet leafhopper does not overwinter in the northern Great Plains of Kansas, Colorado, Wyoming, and Nebraska but moves into these areas in the spring from further south.

A further study of aster-yellows on vegetable crops in Colorado confirmed reports that celery, carrots, and lettuce are most subject to injury. Although they are not so favorable as grasses as hosts of the leafhopper vector of the disease, the degree of aster-yellows infection to carrots and celery varies with number of six-spotted leafhoppers and the degree of viruliferousness of the insects. One field of carrots showed 30 percent obvious symptoms when the population varied from 19 to 30 leafhoppers per 100 sweeps, while in another field there was only about 10 percent infection by 28 to 80 leafhoppers per 100 sweeps. Aster-yellows symptoms do not show when light infestations occur on lettuce, apparently because of the short growing period. Evidence was obtained that field bindweed is an important summer breeding host of the leafhopper and studies were initiated to determine if it is an overwintering reservoir of the aster-yellows virus. The studies showed cheatgrass, a common grass weed in the western States, to be an important host of the insect.

A further study of the source of summer infestations of the six-spotted leafhopper to vegetable crops in the Western Great Plains States indicated that leafhoppers migrate from the southern States during late April, May, and early June. These migrants originate largely in the overwintering area in Missouri and Arkansas, but there is some indication that some may originate in Texas, which may be an important source of summer infestation in New Mexico and southern Colorado. The intensity of the spring movement is apparently governed by overwintering conditions and wind currents during the migration period. Small grain crops are the main host plants during the migration period. They transfer to the vegetable crops after migration is complete and the grain crops are approaching the heading stage.

In cooperative tests with workers of the Crops Research Division in Maryland, the 12-spotted and the striped cucumber beetles transmitted viruses causing cucumber mosaic and squash mosaic. In fifty-four cage tests more than 1500 adult beetles collected from field squash, cucumber and muskmelon were caged, first on infected source plants, then on healthy squash and cucumber seedlings. Squash mosaic was transmitted only occasionally and cucumber mosaic even less frequently. Both viruses were transmitted by mechanical inoculations from crushed beetles of both species, and also from their feces. Beetles that fed on flowers, especially the pollen, appeared to be better sources of the virus. Excessive temperatures during the time most of the work was done may have decreased the efficiency of the vectors. However, the positive transmission of cucumber mosaic by these beetles and the recovery of the virus from their feces confirmed results obtained many years ago in Wisconsin, which had been questioned by other investigators.

Plans: Current studies will be continued at about the same level. Special efforts will be made to determine the effect not only of curly top and cucumber mosaic viruses on the cantaloup crop in Arizona and California, but also of other insectborne virus diseases affecting this crop, such as watermelon mosaic and a tobacco ringspotlike disease. The effect of these diseases alone, and in combination, will be determined in field plots on plants in various stages of development. The occurrence of the diseases will also be correlated with insect flights and field insect populations. This information is essential to a more complete understanding of the problem and the development of methods of disease prevention by vector control.

Publications: Host Plants of the Six-Spotted Leafhopper and the Aster Yellows Virus and Other Vectors of the Virus. R. L. Wallis, USDA Cir. ARS-33-55. March 1960.

Importance of Microscopic Openings in Vector Transmission of Plant Viruses and Bacteria. E. M. Hildebrand. Pl. Dis. Reprtr. 43: 715-718. July 1959.

11. INSECTS AFFECTING VEGETABLES

ENT

Problem: Insects are a limiting factor in the production of high quality vegetables. They reduce the yield, lower the quality, spread plant diseases, contaminate the marketed product, and increase the cost of production. Attempts to control them with chemicals often result in insecticide residue problems. Vegetable growers in every part of the country are concerned about how to control insects more efficiently, and many are finding currently available insecticides inadequate. There is an increasing need for safe, effective, and economical methods of control that will not leave harmful insecticide residues on the marketed product, nor adversely affect the flavor or quality. There is also an increasing need for methods whereby better utilization can be made of predators, parasites, and diseases of the insect pests in order to decrease the necessity for employing hazardous chemicals.

Program: A continuing long-term program of applied research supported by basic insect ecology, physiology, and pathology studies with headquarters in Maryland, South Carolina, Texas, Indiana, Iowa, Ohio, Mississippi, Arizona, California, Utah, Idaho, Oregon, and Washington in cooperation with the respective experiment stations and industry, and involving about 23 professional Federal man-years annually exclusive of basic work on insect physiology, insect pathology, and insecticide residues not covered in this report.

Progress: General progress was made in the development of practical methods of preventing vegetable crop losses from insects and in the development of corresponding measures to protect the health of consumers of vegetables harvested from fields treated with insecticides, as well as to protect persons who handle and apply insecticides or who handle treated crops. Results were made available to extension personnel and farm leaders by the revision of Agricultural Handbook 120, which outlines the insecticide recommendations of the Department for the control of insects on agricultural crops and livestock for the 1960 season and gives precautions for avoiding residue problems. A revision of this publication to give recommendations for the 1961 season is in preparation. Likewise, an intensive program is underway to help distribute the information to growers by revising related Farmers Bulletins and Leaflets of the Department accordingly.

Beans. The work on the biology and methods of control of bean insects was continued in California, Idaho, and Maryland. The relatively safe insecticide, Sevin, was recommended for the first time for use on beans, supported by the establishment of an adequate residue tolerance. Sevin can be used up to 1 day before harvest; it controls the Mexican bean beetle, the potato leafhopper, the corn earworm, and possibly the lima bean pod borer and lygus bugs.

Basic studies in Maryland on the reproduction rate of the two-spotted spider mite, relative to its susceptibility to malathion, showed that increased nitrogen supply to bean plants on which the mites fed caused increased susceptibility of the mites to malathion. However, an increase in the phosphorus supply caused a decrease in susceptibility. The reproduction rate increased as the nitrogen supply and nitrogen absorption into the leaf tissue were increased as long as the carbohydrate content of the leaf tissue also increased. However, at the point where further nitrogen supply and absorption began to decrease the carbohydrate content of the leaf tissue, there also began a decrease in the rate of mite reproduction.

In California and Maryland, phorate and Di-Syston applied to the soil before planting beans continued to give very promising results as systemic insecticides in controlling insects on the foliage. This type of treatment offers economical control of certain bean insects with a minimum of labor and with little chance of interfering with natural enemies of the insect pests. Like all other known insecticides, however, the systemic insecticides thus far tested such as

demeton and phorate, Di-Syston, and dimethoate, are specific for only certain foliage feeding insects. One of the most outstanding new developments in this study was the finding that preplanting soil treatments with systemics will control the Mexican bean beetle. In Maryland, Di-Syston applied in granules at 1 pound per acre in the seed row gave excellent control of the beetle in experimental plots. Similar results were obtained with phorate but dimethoate applied in the same manner did not control the Mexican bean beetle. The Di-Syston and phorate soil treatments continued to give more promising results than other materials tested in California against spider mites and aphids; dimethoate was fairly effective against spider mites.

Eighteen insecticides were tested in field plots in California against the lima bean pod borer and lygus bugs on lima beans. Sevin, Thiodan, and a new experimental insecticide, SD 4402, all gave good results against the pod borer. Thiodan and SD 4402 also controlled lygus, but 2 or 3 applications with ground equipment were necessary. Trithion and malathion also gave fair control of lygus with ground equipment, but airplane applications of Trithion were not satisfactory.

In Idaho continued cooperation was given, in an advisory capacity, to the Bureau of Land Management of the U. S. Department of Interior in the project initiated in 1958 to control the beet leafhopper on seed beans and other crops in southern Idaho by reseeding its desert breeding areas with suitable non-host perennial range grasses. It is hoped that the annual cycle of host plants of the beet leafhopper can be broken by the elimination of its most important summer host plant, Russian-thistle, thereby reducing and perhaps eventually eliminating the beet leafhopper-curly top menace. Approximately 58,000 acres of Russian-thistle was fenced and reseeded in 1958, and an additional 30,000 acres in 1959, primarily with crested wheatgrass.

Studies in southern Idaho showed that weather can quickly cause unfavorable conditions for beet leafhopper. Heavy and excessive rainfall during September 1959 was favorable for the germination of fall, winter, and spring host plants of the beet leafhopper, and they germinated in profusion in most areas before the summer host, Russian-thistle, froze and dried. It appeared that the beet leafhoppers would be able to transfer readily and enter the winter under favorable conditions. However, later examinations of these areas showed that the September rains also caused good germination of downy chess (cheatgrass) an annual that is not a host of the beet leafhopper. This grass intermixed with or crowded out the host plants and created an unfavorable environment for the leafhopper. In addition, warm, extremely dry weather during October, November, and the first half of December caused many of the early germinated host plants to dry up and die. Thus, conditions that looked very favorable for the beet leafhopper in September became very poor by the latter part of December.

In the laboratory, several dozen materials and mixtures were tested for control of the beet leafhopper-curly top complex. The spray mixture of phorate with juice pressed from curly top-resistant beets continued to show most promise for protecting beans and tomatoes, even after the juice had been frozen for a year. In some tests phorate-sugar and phorate-molasses sprays were quite effective but they were not consistently as effective as the phorate-beet juice spray. Urea mixed with beet juice, sugar, or molasses was of no value. Different forms of milk were not effective mixed with phorate. Of nine new insecticides tested, dimethoate and Dibrom, and two experimental materials, were sufficiently promising to warrant further tests.

Results of field experiments in Idaho on the control of the beet leafhopper and curly top with chemicals after the insect reaches bean fields were inconclusive. Phorate used as a systemic continued to give greatest promise but considerable research is needed on the fate of phorate in plants before it can be used commercially on these crops.

A new virus disease that destroys citrus red mites in California had no visible effect on two species of spider mites on beans when tested under greenhouse conditions at Beltsville, Maryland in August and again in January. In August the temperature was high and the humidity low, while in January the temperature was near 70° F. and the humidity high.

Cucumbers and Squash. In South Carolina Sevin was shown to be a good substitute for lindane and parathion in the control of the pickleworm on the fall crops of cucumber, squash, and cantaloup. Parathion cannot be used during the harvest period, whereas Sevin may be used up to 1 day before a picking. Lindane tends to affect the flavor of these crops and subsequent plantings of root crops in the same soil. Heretofore only failure resulted from attempts to find effective substitutes that could be applied between harvests and not leave undesirable residues or cause damage. Sevin will be recommended for the 1961 season. Dimethoate also was as effective in limited tests. Diazinon, Phosdrin, and Dibrom were inferior. Parathion, dimethoate, Diazinon, and ethion were effective against dipterous leaf miners present on the above treated plants but Dibrom and Phosdrin were not. Ethion caused slight injury to the foliage of the plants and did not control the pickleworm. The fruits from Dibrom-treated plots were noticeably lighter in color than those from other plots.

Leafy Vegetables. In California, progress was made in the development of techniques for maintaining disease-free stocks of cabbage loopers for use in studies on the utilization of virus diseases of the insect. The loopers are reared on potted cabbage plants under a protective covering either outdoors or in the greenhouse from sterilized eggs produced in sterilized laboratory rearing cages. Details include meticulous care in handling the insects, steam and hypochlorite sterilization of rooms and equipment, and the use of clean rubber gloves and laboratory coats. Crowding in the greenhouse is avoided by transferring surplus larvae to

outdoor cabbage plots under large cages (10x24 ft.). Breeding stock has been maintained by both reared and field-collected adults. Enough larvae have been produced and purposely exposed to virus disease to build up substantial stocks of virus polyhedra in water suspension. Reasonably pure virus concentrations have been obtained by filtering and fractionation of aqueous suspensions.

In Arizona a dust containing 5 billion spores of Bacillus thuringiensis per gram applied on fall lettuce inhibited the feeding of large salt-marsh caterpillars, but the protection was gone after 8 days. Mortality was greater in the treated plots than in the checks, but it could have been due to starvation as well as toxicity, since there was hardly a trace of feeding.

In South Carolina Bacillus thuringiensis controlled the imported cabbage-worm and diamondback moth in field-plot tests when applied weekly but failed to control the cabbage looper and fall armyworm. The polyhedrosis virus disease of the cabbage looper was as effective as toxaphene against that species, but failed to control the fall armyworm. The virus was not tested against the imported cabbageworm and the diamondback moth. Cage studies indicated that foliage treated with B. thuringiensis spore material was repellent to cabbage looper larvae and that the residual action of the pathogen was less than three days in the field. The mortality of cabbage looper larvae was lower on plants exposed to sunlight and rain than on plants kept indoors. There was no difference in mortality of larvae caged indoors on plants kept moist and on plants kept dry.

In Arizona lettuce fields, tests with various arrangements of spray nozzles on an experimental tractor-mounted trailing boom sprayer-duster showed that nozzles set in the dust tubes to let the airblast from the duster fan drive the spray into the plants gave better control of aphids than the conventional nozzle arrangements. Side dressings of dimethoate granules on young lettuce gave better control of the green peach aphid than sprays of either parathion or dimethoate. Side dressings of phorate or Di-Syston granules were unsatisfactory.

Limited tests in California and Maryland indicated that either Dibrom or malathion now recommended for caterpillar control on cole crops will also control the harlequin bug. They also indicated that Thiodan, toxaphene, and Diazinon are toxic to this insect.

Onion. In field experiments in the Columbia Basin area of Washington, either ethion or Trithion gave excellent control of the onion maggot when used in the furrow with the seed at 1/2 to 2 lbs. per acre in granules. Ethion, Guthion, Trithion, and Diazinon were effective in foliage sprays at a total of 2 lbs. per acre in three applications. In the Walla Walla area malathion and DDT were effective as dusts.

applied to the foliage. In a late summer experiment ethion and Guthion were phytotoxic when used at 1/2 lb. and 1 lb. in granules, and 1 lb. in wettable powder applied to moistened seed. Trithion granules showed only slight phytotoxicity. Dimethoate granules at 1 lb. per acre were not effective.

Peas. In Washington, three species of parasites of the pea aphid from the Parasite Laboratory at Moorestown, N. J. were liberated in March 1959 in alfalfa fields heavily infested with the pea aphid. During the summer and fall both parasitized aphids and adult parasites were abundant for the first time in the area. At least two of the three species survived the winter of 1959-60 and helped to control the aphid on the pea crop. Two of the parasites are native to New Jersey and the other was introduced from India. Apparently, none of them had spread to the State of Washington.

Sweet Corn. In studies to find more effective insecticides for European corn borer control, four insecticides not now recommended (Shell Compound 4402, Dylox, Nematocide 29493 and Sevin) showed enough promise to merit further testing.

Research was continued in Mississippi in an effort to find insecticides that are effective against the corn earworm. Sevin, Shell Compound 4402, and Guthion applied as sprays gave control equal to or better than DDT. Four to six applications were required for control depending upon the severity of the infestation and the uniformity of silking. Four to six applications of granular nematocide 18133 and Shell Compound 4402 applied by hand gave fair to excellent control. When applied by hand Sevin and DDT granules gave poor control but dust gave satisfactory control. Machine application of both dust and granules gave poorer control than when applied by hand.

Field tests of disease organisms for control of the European corn borer continue to look quite promising. Limited tests indicate that clay granules as carriers for Bacillus thuringiensis are slightly superior to water sprays under standard methods of application.

Search for sweet corn resistance to the corn earworm was continued. Since corn sold on the fresh market must be entirely free of earworm injury, intensive efforts are being made to utilize the lethal silk factor in resistance studies. Even if immunity cannot be obtained, corn with a high degree of resistance is desirable in order to reduce the need for a large number of insecticide treatments.

A total of 505 inbreds and 240 single crosses were grown in the study of earworm resistance in sweet corn. Nine inbred lines from a combined

breeding and testing program from Illinois were found to be highly resistant; one of these lines had very good quality, and was completely free of earworms except for dead larvae in the silks. The resistant inbreds developed in the Indiana program continue to show high resistance, and several crosses made from these resistant lines are quite resistant. The cross 230 x 245 had 92% worm free ears in the test in Mississippi, and 10 others had 50 to 90% of the ears free in spite of heavy earworm populations. Many of the inbreds of this resistant group have a history of dead larvae in the silks.

Tomato. In Utah and Maryland, continued studies on methods of control of drosophila in canning-tomato fields confirmed previous indications that granular insecticides are about as effective as sprays, dusts, and bait formulations. The recent approval of the use of aldrin on tomatoes up to 1 day before harvest made this insecticide the most practical of those available for combating this insect. Aldrin was effective both in granules and sprays. Diazinon granules and sprays were almost as effective but cannot be applied within three days before a harvest. Malathion spray was effective but did not last long under field conditions. Pyrethrum-piperonyl butoxide dusts continued to be of value applied to the harvested tomatoes to prevent egg-laying by drosophila while the tomatoes were being transported to the cannery. Of 8 diluents tested for these dusts, walnut shell flour and talc gave best results.

In Maryland, the search for lures for drosophila flies that can be utilized in control programs on the insect was continued. In this program approximately 1300 samples of chemicals or plant extracts prepared by the Northern and Western Utilization and Development Divisions and by the Pesticide Chemicals Research Branch have been screen-tested by the entomologists since Jan. 1, 1960. Only a few have been as attractive to the drosophila flies as the standard attractant, which is only moderately attractive. None have been outstanding.

Plans: The work will be continued along the same lines but with increased emphasis on new biological and chemical approaches to the solution of insecticide residue problems. Consideration will be given not only to vegetables used for food but also to vegetable refuse or by-products fed to dairy and meat animals.

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12. ELECTRIC EQUIPMENT FOR ATTRACTING AND DESTROYING INSECTS AE

Problem: Suitable control has not been found for many insects of economic importance, while chemical resistant strains of other insects are developing, as well as leaving undesirable residues in some applications.

Program: A continuing long-range program in cooperation with the Purdue University Agricultural Experiment Station and with support from the Indiana Electric Association and involving two professional Federal man-years. Its objectives are general improvement of the effectiveness of electric insect traps and related equipment and development and evaluation of procedures for the use of insect traps to protect particular crops, especially home vegetable gardens and tobacco.

Progress: Use of single light traps to protect individual isolated garden plots containing six common garden vegetables was continued and again gave significant reduction of insect damage. Three lighting treatments and an unlighted check were compared and the treatment using 3 BL lamps gave the greatest general damage reduction. Reduction of losses from cucurbit wilt, transmitted by the striped cucumber beetle, was particularly outstanding and significant reductions in damage from potato leafhopper, cabbage looper, tobacco and tomato hornworms and European corn borer were also obtained.

Use of blacklight traps for surveys of economically important insects

was continued in nine North Central States and consideration is being given to greater standardization of equipment and procedures throughout the region for this purpose. Comparative evaluations of trap designs for survey work are in progress as a basis for recommendation of a standard design. Additional traps were also furnished to the European chafer investigations at Geneva, New York for evaluation in surveys for that insect.

Investigations of portable power supplies for insect traps has continued, with emphasis on selecting a commercially available unit of the transistorized inverter type. One such unit, especially designed, seems quite promising and is undergoing additional tests at the Texas station. Studies of the separate effects of insect trap components, such as lamp size, funnel size and lamp placement are also in progress.

Following 3 years of promising experimental results in controlling hornworm moths in tobacco with blacklight traps in Southern Indiana, the traps were installed and operated by the cooperating farmers in 1959. Reduction of damage compared very favorably with that achieved during the original experiment.

Plans: Additional work to substantiate results is needed before either the studies of insect trap designs or the protection of garden vegetables can be accurately evaluated, therefore, another season of similar activity is planned.

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13. PESTICIDE APPLICATION EQUIPMENT

AE, ENT

Problem: There is need for work on the reduction of cost and the improvement of effectiveness of pest control by the development of improved methods and equipment for applying pesticides by aircraft, surface, and soil machines.

Program: A continuing long-term program involving laboratory and field studies of pesticide application equipment for control of plant diseases, insects and soil inhabiting pests involving work on aircraft, ground, and soil equipment, on spray droplet sizes, and on the behavior of aerosols, dusts and granules, with headquarters at Forest Grove, Oregon; Columbia, Missouri; Wooster, Ohio; Beltsville, Maryland; and Ames, Iowa, in cooperation with the Washington State Potato Commission and State Agricultural Experiment Stations of Washington, Oregon, Missouri, Minnesota, Ohio, and Iowa, involving about four professional Federal man-years annually.

Progress: Aircraft Equipment for Application of Pesticides. Joint studies by agricultural engineers and entomologists were conducted on pesticide dispensing equipment. The work included tests of effectiveness in control of green peach aphid on potatoes. Endrin at 0.45 lbs. per acre was used in spray formulations. Sprays applied at 10.7 gallons per acre were more effective in aphid control than at 5.7 gallons per acre rate, with 84.8 percent control and 72.5 percent control respectively. Significantly better aphid control was obtained in a clean cultivated crop of potatoes than in a weedy crop. No correlation was found between wind velocity and control obtained when wind velocities varied from 0.7 mph to 9.2 mph and tests extending from morning to evening. These results coincide with those of 1958 tests, when no difference in aphid control was shown with wind velocities varying between 0-3 mph to 6-8 mph. The use of extended flaps during a spray application did not improve the insect control with endrin sprays.

A series of tests was conducted to determine spray penetration and deposit resulting from aerial application to certain crops. The dye recovery method was used to determine rates of deposit on the sampling areas. Pressure adhesive labels 1/2" x 1" were attached to the leaf surfaces and used as sampling areas. Labels were placed on both the top and under surfaces of leaves at various foliage levels. Tests on potatoes indicated that spray was deposited at the upper and lower plant levels and on both leaf surfaces in varying degrees depending upon position on the plants. The highest deposits were at the top of the plants with reduction in deposit and coverage toward the ground. Similar results in general were found in tests on pole beans and corn. Further developments in techniques for this type of testing and evaluating spray equipment is needed.

Some individual tests on the N3N biplane with and without the use of a spoiler mounted under the center of the fuselage in various positions indicated that the normal crossover of spray from right of center to left of center could be controlled by properly positioning a spoiler. Replicated tests using the same spoiler position and nozzle arrangement,

however, showed that variations in swath patterns were as great as the differences found in patterns with and without the use of a spoiler.

Spray Equipment for Control of Insects and Diseases by Ground Machines. Work continued on the development of equipment and techniques for the application of insecticides and fungicides to crops by ground machines. No significant difference was shown between application rates of 20 and 40 gallons per acre in control of anthracnose and foliage diseases of canning tomatoes. Sprays applied down the row or with the air and spray pattern directed parallel to the rows was more effective than the customary method of spraying across the rows at right angles. The development of equipment for harvesting canning tomatoes no doubt will result in closer planting and must receive consideration for equipment and methods of spraying. One exploratory test was run with the customary 2500 plants per acre compared to 5000 plants per acre. Control of disease was not significantly different for either plant population. A special spray formulation of colloidal copper was compared with Maneb for disease control on tomatoes using the air-blast sprayer. The colloidal copper was not effective in control of anthracnose while the Maneb gave satisfactory disease control. Hydraulic spray applications at 20 and 40 gallons per acre were as effective as 160 gallons per acre. In all comparisons the same amount of fungicide was used per acre.

Studies were continued with the trailing boom type sprayer developed in cooperation with the Agricultural Experiment Stations of Oregon, Washington and Idaho and Entomology Research Division, ARS. Emphasis is being placed on penetration and uniformity of leaf coverage. Combinations of nozzle positions and patterns are a major consideration. Pressure adhesive labels and dye recovery method is used to measure rates of spray deposit. Results to date have shown somewhat irregular deposits on the foliage.

Spray Atomization and Relation to Pest Control. Field experiments were conducted to determine the effect of drop size of a spray on the pesticidal results. Fungicidal sprays of controlled mass median diameter were applied to randomized, replicated tomato plots. The fungicide, Manzate, was applied at half the recommended rate to intensify differences in disease infection. Effectiveness of spray treatments was measured by net yield, anthracnose and early blight infection on fruits and percent defoliation. Two series of flat spray patterns ranging from about 100 microns to 500 microns mass median diameter were applied. One series was applied at 40 gallons per acre and the other at 15 gallons per acre. Mass median diameters were varied by 100 micron increments by changing spray pressure. A similar series of hollow cone sprays ranging in mass median diameter from about 100 microns to 400 microns was applied at 40 gallons per acre. Differences in disease infection and yield were not significant and show little relation to drop size for any of the spray patterns or application rates used in the experiments. The lowest percent defoliation occurred in the plots sprayed by a hollow cone

pattern of small mass median diameter. Variation in operating pressure apparently affects the drive of the spray material as well as drop size, and the technique for measuring this factor might contribute to the evaluation of the results of such experiments as these.

Equipment for Application of Chemicals to Soil for Control of Soil Pests. The object of this project is to develop equipment and techniques for the chemical treatment of soil for the control of pests in orchards, forest nurseries, ornamental plantings, vegetables, and other crops. The field experiments were done in cooperation with the Department of Botany and Plant Pathology and Department of Entomology, Ohio Agricultural Experiment Station. Liquid and granular forms of nematocides, herbicides, insecticides, and fungicides were applied to soil in which various crops including vegetables, ornamentals, locust tree seedlings, tobacco, and grape cuttings were grown. Nylon, teflon, stainless steel, neoprene, polyethylene, and bronze materials have given good service in the application equipment used in making these treatments. The field cultivator with spring-type shanks proved to be readily adaptable to row treatments and easily set up on a tool bar for different full width treatments. The full width and row-type rotary tiller also met field requirements very well. A device for laying plastic film to retain a highly volatile fumigant as it is applied was prepared for use with these applicators and used at several locations during the season.

Weed Control. Cooperative studies were conducted to evaluate various granular formations and to determine the methods and equipment required for accurate and efficient application. Granular size and percentage formulation studies indicate that uniformity of distribution is not highly critical inasmuch as 4 granules per square inch were as effective as 50 granules per square inch. Laboratory trials where granules were caught on glass plates show that all of the commercially available spreading devices could be improved. Working granular herbicides into the soil with a rotary hoe at application time did not materially affect the weed control obtained. Evaluated in terms of weed control in the field, flutes, augers, fluted shafts, gravity feeds, and reciprocating chains are some of the mechanisms that will satisfactorily meter granular herbicides. Fan-type spreading devices, inverted cones, and splash-plates were used to obtain uniformity of spread of granules on the soil surface. Approximately equal weed control was obtained with all spreading mechanisms.

A device was developed in Mississippi for the soil-incorporation of experimental volatile herbicides in the top 2 to 6 inches of soil surface. The most effective results to date have been obtained by placing a 16 inch treated band under the surface of the soil with a wide angle nozzle tip behind a special underground applicator. A technique of using a fluorescent tracer that can be photographed for studying herbicide spray

deposits underground was developed and will be of great value to this work to be continued in this area. Similar work was done in California in an effort to activate the pre-emergence chemical by incorporating it in the top layer of moist soil. A test vehicle including various soil mixing devices was built for these tests. Of the materials used, two showed promise of being successfully activated by the moisture available in the soil at planting time.

Small Particle Behavior. A study was continued to provide basic theoretical concepts and experimental data needed for development of pesticide application equipment and techniques which have optimum depositing efficiency and distribution characteristics. Because of the effect of particles upon each other, it has been found that behavior of groups of particles cannot easily be predicted from the behavior of single particles. A study has been initiated which attempts to describe particle behavior from a statistical point of view.

A scanning type of instrument is under development for measuring the distribution of chemicals on plants. An intense beam of ultraviolet radiation is directed upon a rotating cylinder or disk upon which the treated sample is to be mounted. The visible fluorescent light emitted is sensed by a microscope-microphotometer system, and the signal is fed into an appropriate recorder. An instrument enclosure and ultraviolet illumination system have been designed and constructed.

Plans: Improved granular dispensing equipment for aircraft will be developed and tested. Lower rates of application and evaluation of swath distribution and foliage coverage with air blast sprayers will be investigated. Tests will be conducted in an effort to improve uniformity and coverage of the row crop sprayer duster. Study of small particle behavior will be extended.

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14. PLANTING AND FERTILIZING EQUIPMENT AND PRACTICES

AE

Problem: To determine the most effective and economic ways and means of establishing crops and applying fertilizer.

Program: Continuing long term program of cooperative research involving studies of fertilizer placement and seed placement investigations is in progress at 34 locations. Approximately 7 man-years are devoted to this work. A small portion of this work which deals with vegetables is reported here.

Progress: In using radioactive phosphate fertilizers on tomatoes in Georgia, the use of heavy fertilizer rates below the seed at time of planting gave greater production of marketable tomatoes. Plants were transplanted in New Jersey and grown for fruit production - 18 tons per acre (10 lbs. P_2O_5) to 25 tons per acre (130 lbs.) on total production. Probably equal, if not more significant was the increase of early production of tomatoes. The early production varied from 1/4 ton to 1-1/2 tons per acre. The net returns to the grower for early production are many times larger than production during the peak of the season.

Plans: Studies on the effect of fertilizer placement on early tomato production will be continued.

15. ANALYSIS OF FARM COSTS

FE

Problem: Farmers, research workers, and commodity analysts need more information on production costs in order to ascertain the effects of new technology on returns and on comparative advantage among producing areas. Growers and employment agencies need up-to-date labor requirement information in order to plan for recruitment and placement, and the USDA needs cost and labor information to improve its statistical series on farm labor requirements and productivity.

Program: One part of a continuing national study of changes in farm production practices and costs for major farm commodities was the survey conducted for the year 1959 of production practices, labor requirements and costs of producing major truck crops in 12 major producing areas of the U. S. The survey was made by a private research firm under contract. It involves about one Federal professional man-year.

Progress: The field work was completed in March 1960 and tabulations were received from the contractor in July 1960. A total of 2,496 producers of truck crops were interviewed. These growers harvested a total of 218,639 acres of truck crops - 79 percent for fresh market use and 21 percent for processing. Final statistical tables are being prepared showing for each area operations performed, equipment used, and labor and material requirements. A separate report is in preparation showing the extent that truck crop producers enter into contractual agreements with production, processing, and marketing firms.

Plans: The statistical tables will be completed and manuscripts prepared for publication. Data will also be incorporated into the statistical series on farm labor requirements and productivity.

II. UTILIZATION RESEARCH AND DEVELOPMENT

A. Chemical Composition and Physical Properties

1. CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF VEGETABLES WU, EU, SU

Problem: Lack of adequate knowledge of the nature of the chemical constituents and enzyme systems in vegetables, and of their physical properties, is impeding research on the development of new and improved processes and products.

Program: A continuing program of fundamental research, involving nine professional Federal man-years per year and two professional industry-sponsored man-years per year, is being conducted at Albany and Pasadena, California on the chemical basis of vegetable flavor (including work supported by the National Cannery Association), the retention of chlorophyll in processed green vegetables, the relationship of dry bean components to cookability, and composition of lima beans (supported by the California Lima Bean Advisory Board). Fundamental compositional studies on dry beans are being conducted by contract at the University of Idaho in relation to cooking quality and at the University of Illinois and at the Standard Research Institute in relation to physiological response to ingestion of various bean products. Compositional studies of processed green vegetables to develop improved methods of analysis for chlorophyll and its degradation products is being conducted by contract at Brigham Young University. In addition, fundamental research is being conducted at Aberdeen, Scotland and Chipping Campden, England under Public Law 480 on the oxidation of carotenoids from vegetable products and on the role of phytin in the cookability of dry peas.

Work on celery flavor components at SU's Winter Haven, Florida laboratory involved approximately one professional Federal man-year.

Cooperative work between EU and the U.S. Plant, Soil and Nutrition Laboratory at Ithaca, New York on constituents of kidney beans involved about one professional Federal man-year.

Progress: The Chemical Basis of Vegetable Flavor. Flavor is a sensory response to chemical reaction. The quantities of reactants involved may be incredibly small, yet laboratory techniques have been developed at WU that allow a substantial exploration into the chemical nature of vegetable flavor. Emphasis of current work is on the volatile components of onions, enzyme mechanisms and substrates involved in flavor development in onions and other vegetables, and the chemistry of flavor changes accompanying the processing and storage of green peas. (The last investigation is supported by the National Cannery Association.)

An enzyme preparation was obtained from onions that is specific for the hydrolysis of S-alkyl-cysteine sulfoxides. The addition of the enzyme to boiled or dehydrated onions intensified their flavor. A corresponding flavor-producing enzyme had been found by others in garlic, but this is the first recorded example of such a component of onions. When the enzyme was added to dehydrated cabbage, known to contain S-methyl L-cysteine sulfoxide, a momentary, sharp, lachrymatory odor was produced. The enzyme had no effect on the sulfur-containing amino acid, "cycloalliin," newly discovered in onions. However, the status of this amino acid as an immediate flavor precursor in onions has not been completely ascertained.

Five principal volatile carbonyls were identified from onions as: acetaldehyde, acetone, propionaldehyde, n-butyraldehyde, and methyl-ethyl ketone. A sixth was not identified but appeared to be an unsaturated aldehyde or ketone. Several alkanethiol alkylsulfinates, alkanethiol alkanesulfonates, and aryl derivatives have been synthesized in a pure state. The thiolsulfinates have sharp pungent odors and propanethiol-propanesulfinates has an odor suggestive of the pungency of fresh onion. Procedures that were developed for separation of sulfur-amino acids will be useful to isolate these compounds from onions.

The enzymic breakdown of the sulfur-containing amino acid, methionine, was accomplished with a preparation of subcellular particles from cabbage leaves that released the carboxyl group as CO_2 . The metabolism of methionine plays a key role in the natural synthesis of other amino acids and, in particular, is believed important in production of sulfur-containing flavor components.

A new technique of flash-exchange gas chromatography was developed for rapid and semi-quantitative identification of volatile carbonyls, aliphatic acids, and mercaptans. This development led to the identification in peas of acetaldehyde, acetone, propionaldehyde, n-butyraldehyde, n-valeraldehyde, formic acid, acetic acid, iso-valeric acid, hydrogen sulfide, and dimethyl sulfide. The technique should have general application in food chemistry.

Celery Flavor Components. Distillation at SU of the expressed juice from approximately $1\frac{1}{2}$ tons of celery in a pilot-plant essence recovery unit yielded about 2 ml. of essential oil which was found to be approximately 90 percent d-limonene. Another compound gave absorption spectra indicating the structure of alpha-phellandrene. Concentration of the extract yielded a solution with a strong, characteristic celery odor. Further partition indicated the presence of several compounds; but the quantity of material was too small for isolation or identification of any specific constituent.

To provide a sufficient amount of the flavor and odor volatiles for separation and characterization, over three tons of celery were blanched, hydraulically pressed, approximately 400 gallons of the juice distilled in the essence recovery unit and the volatiles condensed. In addition, about 45 gallons of juice were canned in three lots at different processing temperatures. These juices will be used in preliminary studies to compare the distillates with those from the fresh juice. Since most processed products incorporating celery or celery juice receive some heat treatment, examination of the canned juice will provide some insight into the difference between the fresh and the cooked celery flavor.

Taste panel comparison of the juice of celery tops (mostly leaves) and the juice of the entire stalks revealed a highly significant difference. The finding suggests that it may be desirable eventually to study the individual parts of celery separately.

Retention of Chlorophyll in Processed Green Vegetables. Color characteristics influence the acceptability of preserved green vegetables. Generally the most highly accepted products are those in which garden-fresh green color of the chlorophylls is retained without chemical change. Fundamental studies on the conversion, during processing and storage of preserved vegetables, of chlorophylls a and b to brownish-green analogs, pheophytins a and b, and other products of degradation have continued at WU. Analytical techniques for chlorophylls and pheophytins have been subjected to definitive scrutiny, by a contract investigation at Brigham Young University, and suitable methods for separation and measurement of the chlorophylls and their degradation products have been concluded.

The standard method for measurement of conversion of chlorophylls to pheophytins involves a simplifying assumption that a two-component system, rather than the actual four major components, exists in extracts of acetone-soluble vegetable pigments. Purified chlorophylls a and b were prepared from fresh spinach leaves and pheophytins a and b from these by treatment with oxalic acid. Absorption curves for the pure components were determined spectrophotometrically, and appropriate wave lengths chosen that avoided interference with other soluble pigments. A mathematical formula, involving simultaneous equations, was developed to establish the concentration of each of the four components when combined in solution. Application of the technique to mixtures of the components was usually found to agree within one or two percent of a theoretical value based on magnesium content. The ratio of chlorophyll a to chlorophyll b was determined in samples of fresh and frozen green vegetables in the initiation of a study of variability of this factor between varieties and samples of a particular green vegetable, and the influence of processing and storage on pigment degradation.

Radial paper partition chromatography techniques to isolate and identify chlorophylls and their degradation products relative to preservation processes were advanced. Removal of interfering pigments by column chromatography was necessary prior to development of well resolved radial chromatograms. Canned and frozen peas were studied in preliminary work but replaced later by frozen spinach, which was found to be relatively free of interfering lipids. After methodology is perfected, work with other green vegetables will be continued.

Pure solutions of chlorophylls were isolated for preparation of known derivatives. The physical constants, obtained by radial chromatography of such known compounds including the chlorophylls themselves, will be useful for comparison with unknown bands on chromatograms developed from extracts of processed green vegetables.

The Relationship of Bean Components to Cookability. Many starch foods cook tender in the relatively short time required to bring starch to the gelation temperature (about 170° F.) in the presence of adequate water. Soaked dry beans frequently require more than an hour of boiling to cook properly. The slow cooking rate, as well as the long soaking time required for bean hydration, have long been recognized as important limitations to the increased utilization of beans as food products. A device for measuring the time required to cook beans, and micro methods for analysis for calcium, magnesium, phosphate, and phytic acid, have been developed at WU. By these methods compositional data may be obtained on one cotyledon of a bean; cookability, on the other cotyledon. Thus correlations may be drawn without interference from individual variations from bean to bean. A distinct relationship between the cookability of dry peas and the calcium, phosphate, phytic acid system has been observed elsewhere. The existence of such a relationship for dry beans may be demonstrated by the new technique.

In contract studies conducted at the University of Idaho, extensive compositional data were obtained on eight lots of legume seeds, including lima beans, blackeye beans, fava beans, dry peas, and four varieties of common beans. The data are to be compared with organoleptic evaluations and physical measurements of cookability for the same lots. To date the following components have been reported for the eight lots: moisture, crude lipids, ethanol-soluble nitrogen, and total and reducing sugars. No striking differences were encountered among the various types of beans. Because of the higher prevailing humidities in Michigan, two lots of beans from there were about 5% higher in moisture content than lots from Nebraska, Idaho, and California. The dry peas (Alaska variety) were a little higher in protein content and slightly lower in total sugar than the beans. Lima beans were slightly lower in protein than the other samples.

Physiological Activity of Dry Beans. Industry spokesmen almost unanimously agree that more dry beans would be used if it were not for the widely held opinion that beans are responsible for intestinal distress and flatulence that may follow their ingestion. Separate but

related investigations by WU are concerned with indirect and direct measurements of the effects of bean diets and the effects of bean products and bean components on intestinal phenomena in laboratory animals.

An investigation of indirect methods for measurement of flatulence in humans, conducted under contract at the Stanford Research Institute, has been concluded. The indirect methods included analysis of exhaled breath, analysis of gases produced by anaerobic fermentation of fecal samples from normal subjects and ileostomy and colostomy patients, and intestinal motility evaluation by use of a dye marker. A significant amount of methane or hydrogen in exhaled breath samples could originate only by anaerobic fermentation in the gut. In some subjects methane could be measured in breath samples by long-path infrared spectrometry. Hydrogen could not be detected in breath samples with available equipment. Breath methane was an indication of intestinal sluggishness in some of the subjects tested, but it was not a reliable indication of the distress and flatulence that followed ingestion of beans. Fermentation gases from fecal samples indicated a narrow range in the level of CO_2 , CH_4 , H_2 and N_2 with some increase in CH_4 following bean ingestion with some subjects. Analyses of flatus from the same individuals showed considerable variation in replicated tests, but it was difficult to conclude that a consistent change in flatus composition was due to bean ingestion. Fecal gases from ileostomized and colostomized patients indicated that hydrogen may be produced (by fermentation) in the ileum and methane in the colon during the most active period of gas production.

Related studies on the effects of bean diets were initiated by contract with the University of Illinois. Diets containing 25 and 50% beans were compared with diets containing no beans. With a 25% bean diet, flatus increased (by direct measurement) 8-fold during the first week and 12-fold during the second week when compared with a bean-free diet. On the 50% bean diet the comparative increases were 10-fold and 60-fold. Flatus composition varied with amount of beans ingested, for example, CO_2 content with no beans in the diet ranged from 7-11%; with 25% bean diet, 20-23%; and with 50% bean diet, 37-53%. Oxygen, hydrogen, and nitrogen decreased in percentage as carbon dioxide increased. Methane content usually showed a small increase. Feces increased in bulk and weight on the bean diets with part of the increase resulting from higher moisture content. Nitrogen content of the feces also increased but there was little change in the nitrogen balance of the subjects.

These data represent the first objective data supporting the widely held belief that ingested beans cause flatulence in man. A reliable, if somewhat tedious, method for directly measuring flatus has been demonstrated; it can be used to examine further the causative factor(s) and may lead to improved dry bean products.

The relationship of components of beans to intestinal reactions in rats has been further investigated. Saponin derived from dry beans or from alfalfa caused hyperemia, increased motility, and gas or mucous distension of the gut when injected into the intestinal canal.

The Composition of Lima Beans. Large dry lima beans are produced within narrow geographic boundaries in the State of California. To assure coordination of dry lima bean research with investigations of other types of bean, research on the components of this product has been supported by the California Lima Bean Advisory Board at WU. Continuing investigations revealed a relatively high level of highly unsaturated fatty acids in the lipid fraction of lima beans. Comparative results from blackeye beans and three varieties of common beans indicate that similar results may be expected in many legume seeds.

The effect of maturation on composition of beans was studied for the second harvest season. With informal cooperation of the University of California's South Coast Field Station, large lima beans were harvested at various stages of maturity and tested for total nitrogen, amino nitrogen, and free amino acids. While general results confirmed the previous year's finding that growth processes are attended by decreasing moisture, amino nitrogen, and amino acid content, the second year's results varied considerably in the details. Replicated studies over several years will be required to establish the limits of variation and detailed compositional character of lima beans.

Nitrogenous Constituents of Kidney Beans. Analyses of the soluble and insoluble nitrogen components of kidney beans were continued at EU. Acid hydrolysates of the nitrogen fractions were found to contain a non-nitrogenous organic acid which was identified as levulinic acid. This is a significant basic contribution in that it has been demonstrated that certain non-nitrogenous constituents, in addition to levulinic acid, can yield colored reaction products with ninhydrin, a reagent which has been employed almost exclusively for the detection of amino acids. This work has been completed.

The Role of Phytin in the Cookability of Dry Peas. Fundamental studies on the effect of the phytin and related phosphorous-metallic compounds on cookability of dry peas, to improve quality of dry peas, is being conducted under P. L. 480 by the Chemical Laboratory of the Fruit and Vegetable Canning and Quick Freezing Research Association, Chipping Campden, England. The role of phytin and phytase on the cookability of dry peas has been known on the basis of empirical experiments conducted elsewhere. Analytical methods for determination of inorganic and phytin phosphorous were devised and pure pea phytin was prepared and tested.

Compositional factors of peas dried under different conditions, composition of pure phytin, distribution of calcium and magnesium, and ion balance between phytin and pectin are being determined in continuing

research to further elucidate the chemical mechanisms by which calcium and phytin affect cookability of dry beans.

Oxidation of Carotenoids from Vegetable Products. Fundamental studies on the chemistry of the oxidative and other types of deterioration of carotenoids, occurring in the processing and storage of vegetable products, as a basis for improved stability of preserved yellow vegetables, are being conducted under P. L. 480 at the Aberdeen, Scotland Research Establishment and Experimental Factory of the British Ministry of Agriculture. Studies on the degradation products resulting from exposure of all-trans beta carotene to oxygen were initiated. Products were isolated by selective extraction and chromatographic procedures and characterized for comparison with carotenoids isolated from processed vegetables.

Relative amounts of various carotenoids were determined for fresh and freeze-dried carrots. No discernible differences in amount were found as a result of this process.

Plans: The greater part, and if necessary all, of the research effort within the next several months at SU will be devoted to the isolation, identification, and chemistry of the flavor constituents contained in each of the several fractions of volatiles entrapped during distillation of the juice in the essence recovery unit.

Compositional studies on vegetables at WU will be continued on the elucidation of flavor constituents and of the chemical mechanisms of flavor release and flavor changes in processed vegetables (including peas, onions, and cabbage); the measurement of chlorophyll and its degradation products as affected by processing and storage of processed vegetable products; relationship of dry bean and pea constituents to cookability, and of beans to the physiological response to ingestion of bean products; and the deterioration of carotenoid pigments by oxidation during the processing of vegetables and storage of products.

Publications: A Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures. J. F. Carson, W. J. Weston, and J. W. Ralls. Nature 186, (4727):801. 1960.

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Chemical Inactivation of Enzymes in Vegetables before Dehydration. R. U. Makower. Food Technol. 14 (3):160-164. 1960.

Quality of Cabbage Dehydrated after Chemical or Steam Inactivation of Enzymes. R. U. Makower and M. M. Boggs. Food Technol. 14(6):295-297. 1960.

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Formate Oxidation by Particulate Preparations from Higher Plants. M. Mazelis. Plant Phys. 35 (3):386-391. 1960.

Another Comparison of a Glucose Oxidase Method with an Official Method for the Determination of Fructose. Earl F. Potter, John R. Wilson, and Kenneth T. Williams. Jour. Assoc. Off. Agr. Chem. 42 (3):650-52. 1959.

Flash Exchange Gas Chromatography for the Analysis of Potential Flavor Components of Peas. J. W. Ralls. J. Agri. and Food Chem. 8 (2):141-43. 1960.

Rapid Method for Semiquantitative Determination of Volatile Aldehydes, Ketones, and Acids -- Flash Exchange Gas Chromatography. J. W. Ralls. Anal. Chem. 32 (3):332-336. 1960.

Nitrogen Compounds of Cabbage, I. The Relation of the Non-Protein to the Total Nitrogen with Special Reference to the Amino Acids. Edward G. Kelley, Robert M. Zacharius, Samuel Krulick and Reba Baum Greenspun. Food Research 25, 399-413. 1960.

Nitrogen Compounds of Cabbage. II. Chromatographic Analysis of the Non-Protein Nitrogen. Robert M. Zacharius, Edward G. Kelley, and J. J. McGuire, Food Research 25, 414-418. 1960.

2. CHEMICAL ATTRACTANTS FOR DROSOPHILA

WU

Problem: The utilization of several fruits and vegetables is being seriously affected by infestations of Drosophila (vinegar flies) in processing plants. Although they do not constitute a hazard to health, Drosophila eggs are considered by regulatory officials as adulterants indicating unsanitary conditions in the packing plant, rendering products unfit for human consumption. Contamination of products by Drosophila results in economic loss to both the processor and the grower.

Program: A program of basic research, involving one professional Federal man-year per year, is being conducted on fruit and vegetable components that are attractants to Drosophila. Components are being isolated and concentrated and supplied to entomologists in other agencies to test for their application as baits for use in control of Drosophila.

Progress: Materials from fermenting mixtures known to attract Drosophila are being isolated and tested (by the Entomology Research Division, ARS) by comparison with a standard lure which has been used as an attractant

for Drosophila. Nearly 1,000 preparations have been isolated and tested. None has equalled the attractiveness of the lure, but there is a wide variation between the different preparations tested. This indicated that fermenting mixtures at certain stages may be more attractive than those at earlier or later stages of fermentation.

In research at Albany, California activated charcoal was found capable of adsorbing the attractive volatile materials that are elaborated by a fermenting mixture. In order to isolate and identify volatile products from a fermenting mixture of yeast, sugar, and water, the reaction vessel was swept by an air stream that was then directed into a solution of 2,4-dinitrophenylhydrazine. A precipitated material of at least two compounds was formed. Steam distillation of the fermenting mixture yielded an abundance of acetaldehyde. Acetaldehyde and other carbonyls appear to play a role in the attractiveness of fermenting mixtures for Drosophila. A gas chromatography apparatus has been constructed to aid in the separation and identification of compounds present in attractant mixtures.

Plans: Work on the chemistry of Drosophila attractants will be continued in cooperation with other USDA agencies. Specific compounds or class of compounds obtained from fermentation mixtures that have been found attractive to Drosophila will be studied for their ability to attract or repel the species.

B. New and Improved Food Products and Processing Technology

3. NEW AND IMPROVED PROCESSED PRODUCTS FROM SWEETPOTATOES SU, EU

Problem: Increase the utilization of sweetpotatoes through improvement in quality of existing processed products and development of new and improved products, particularly precooked dehydrated flakes.

Program: A continuing long-term program involving chemical, physical, and engineering studies in the laboratory and pilot plant; carried out at the Southern Regional Research Laboratory, New Orleans, Louisiana, in cooperation with the Louisiana Agricultural Experiment Station and the Quartermaster Food and Container Institute for the Armed Services; involving about four professional man-years annually, of which about one man-year was paid by QMF&CI funds through part of 1959-60.

The development of a process to make satisfactory dehydrated mashed sweetpotatoes in flake form and frozen French fried sweetpotatoes from Eastern grown (dry type) sweetpotatoes has been conducted at the Eastern Regional Research Laboratory and involved one Federal professional man-year.

Progress: Instant Sweetpotatoes. In continued work at SU, with the cooperation of the Quartermaster Food and Container Institute, consistent production of high quality sweetpotato flakes having "instant" rehydration properties has been accomplished on a small pilot-plant

scale. Continued retention of good flavor and other quality characteristics by suitably processed and packaged products for well over a year has been demonstrated.

Experiments to test the effects of graded levels of antioxidant additive (Tenox VI), and of oxygen in the packaging atmosphere have shown to date that only under nitrogen, with less than 2% oxygen content, have the flakes remained flavor stable at all levels of antioxidant and retained approximately their original contents of carotene and ascorbic acid. Should continued tests verify the trends so far indicated, the oxygen tolerance and required levels of antioxidant required under varying packaging conditions will have been ascertained.

Evidence so far obtained in investigation of the possible role of beta-carotene, or other carotenoid constituents of sweetpotatoes in development of off-flavors and odors in the flake product does not incriminate the carotenoids. Application of techniques devised in investigations with colored grapefruit showed that the ratios of the various carotenoid constituents in the raw sweetpotatoes and in both good and deteriorated flakes was about the same, although the total carotene was lower in the latter.

Work was pushed during the year in design, construction, and equipment of large pilot-plant facilities to scale up the sweetpotato flake process to semi-commercial proportions, simulating actual manufacturing conditions. Good progress has been made, with delivery and installation of most of the equipment.

Late in 1959 the cooperating Quartermaster Food and Container Institute was sufficiently impressed by the possibilities of the sweetpotato flake product for use in quick-service ration kits to place with SU procurement order for over 500 lbs. of the product for larger-scale evaluation. In a later noteworthy development, a further contract has been placed to assist implementing an industrial mobilization study and provide 750 lbs. of flakes for further evaluation.

Interest by members of the sweetpotato and other food processing industries in potential commercial exploitation of the flake product is expanding and intensifying at a rapid rate.

Continued pilot-plant research at EU on the drum drying of mashed Eastern dry type sweetpotatoes has shown that production rates per square foot of drum area are much lower with sweetpotatoes than with white potatoes. This is due to the much poorer adherence of the sweetpotato mash to the drum surface.

While it indicated that the double drum drier may be more efficient with mashed sweetpotatoes than the single drum, it is nevertheless feasible

to produce sweetpotato flakes in a white potato flake plant employing the conventional single drum drier.

Preliminary research at EU showed a great difference in behavior on the drum of the Eastern dry type vs. the Southern wet type sweetpotato. The former yields a continuous (though lacy) sheet while the latter tends to "crepe" at the knife due to its thermoplasticity.

Experiments with Maryland Golden variety (Virginia-grown) showed that cooking losses can be reduced from about 30% of the total solids when boiled in plain water to about 10% by boiling in water containing 16% sugar by weight.

Frozen French Fried Sweetpotatoes. Experiments on the stored 1959 crop were completed at EU. Panel evaluation of the frozen French fried sweetpotatoes indicated that a frying time of 3 minutes at 275° F. is adequate to produce a desirable product. This short frying time is important because it permits higher operation capacity of commercial fryers. Frozen French fried yams have recently been introduced to the retail trade by an Arkansas food processor.

Plans: Work will continue at SU to carry experimental production of sweetpotato flakes to semi-commercial pilot-plant scale; to determine optimum moisture, and to evaluate different antioxidants to improve flake stability; to determine the equipment and processing conditions most suitable and economical for commercial operation; produce sufficient quantities of the product for adequate evaluation of its acceptability for military rations and civilian consumer use; and estimate commercial manufacturing costs.

Pilot-plant research at EU on sweetpotato flakes has been discontinued since the SU pilot-plant is now ready to operate. No further work along this line is anticipated at this time. Work in frozen French fried sweetpotatoes will be confined to the preparation of samples on request from interested commercial organizations.

Publications: Sweet Potato Dehydration. Interactions Between Copper Ions and Sweet Potato Polyphenolase Oxidized Substrates. Jett C. Arthur, Jr., and T. A. McLemore. J. Ag. and Food Chem. 7:714-716. 1959.

4. IMPROVED CUCUMBER PROCESSING

SU, EU

Problem: Increase the utilization of cucumbers, through reduction of losses and improvement of quality in cucumber fermentation, and development of new and improved pickle products.

Program: A continuing long-term program involving basic and applied microbiological and chemical studies; carried out in SU's Food Fermentation Laboratory, Raleigh, N. C., and in commercial plants in the South, East, and Great Lakes area, in cooperation with the North Carolina and Michigan Agricultural Experiment Stations, the National Pickle Packers Association, and the pickle industry; and involving about two professional Federal man-years annually.

Progress: Control of Bloaters (Hollow Pickle) Formation in Cucumber Brining. Studies on control of bloater formation in cucumber brining at two commercial plants demonstrated that mechanical piercing large-sized cucumbers before brining reduced bloaters. Pricking the tissue to a depth of about 1/4 inch was less effective than was complete piercing. Additional tests under commercial conditions will be required to fully evaluate the potential for this means of bloater control. Furthermore, development of high-speed pricking and/or piercing machinery will be essential to handling large quantities of green material.

Evaluation of data from a three-year investigation of the effect of sorbic acid on yeast fermentation associated with bloater formation, reveals that the additive drastically suppressed yeast populations in fermentations at the various brine concentrations employed. However, the chemical did not eliminate the organisms. Furthermore, the results indicated that pattern of species occurrence with or without sorbic acid can be most similar. There is the danger in the use of sorbic acid and its salts that, given time, the yeast flora might develop a high degree of tolerance. Aside from this potential short-coming and the cost, it appears that successful use of sorbic acid may require closer technical control than most pickle plants would be able to provide.

Influence of Salt on Pectinolytic Softening of Cucumbers. Experimental packs of pasteurized cucumbers were treated with pectinase from three sources (commercial enzyme 46 AP, fungal filtrates, and purified pectinase) under controlled conditions with respect to temperature, pH, acidity, salt concentration, and absence of microbial development. The enzyme-treated lots revealed that, as the salt content of the cucumbers increased, their firmness likewise increased according to a first order reaction. Pectinase from the three different sources gave comparable results in cucumber softening activity and responded essentially the same to the inhibitory effect of increasing salt levels. The data obtained permit an estimate of the relative degree of pectinolytic softening that may be expected in curing brines at different salt concentrations.

Softening Enzyme Inhibitors. Continued investigation of natural plant inhibitors of the enzymes responsible for softening spoilage of cucumbers in brining, included a water-soluble substance in grape leaves which inhibits the enzymatic hydrolysis of soluble cellulose (sodium salt of carboxymethylcellulose). The mature leaves of six varieties of grapes

of the muscadine group (*Vitis rotundifolia* Michx.) were found to be good sources of the inhibitor. The reduction obtained in cellulase activity was directly related to the concentration of the inhibitor. Cellulase from the fungi on cucumber flowers was more sensitive to inhibition by the grape leaf substance than were four commercial cellulases. The inhibiting substance in the crude grape leaf extract was stable to heat, to weak acid and alkali, and to protein precipitating agents, such as trichloroacetic acid. It was nondialyzable through cellophane or collodion membranes against water or weakly buffered solutions after three days. The inhibiting substance is not related in structure to carbohydrates or proteins and appears to be a large molecular weight organic constituent, probably a phenolic compound.

Work on the chemical identification of inhibitor(s) for pectinolytic (pectin splitting) enzyme activity was continued at EU in cooperation with SU. Isolations of anti-pectinolytic fractions from Scuppernong grape leaves were made and tested for activity. Studies were made on analytical methods which could be adapted to this type of investigation. Isolation of fractions and correlation of activities with known components will be continued.

Microbial Changes Occurring on Pickling Cucumbers Exposed to Different Preprocessing Temperatures and Humidities. Basic information of this type has been lacking to date. Four major tests, of about one week's duration each, were run consecutively during the 1959 cucumber growing season in facilities designed to maintain carefully controlled temperatures of 50°, 60°, 70°, and 80° F., and relative humidities (RH) in the ranges 55-60%, 70-75%, and 80-85%. At the two lower temperatures cucumbers held for as long as 6 days showed rather small increases in total microbial populations except at the highest humidity. At 70° F., the 6-days increase in count was more pronounced and was very marked at 80-85% RH. At 80° F., even after 4 days, the microbial populations had increased from around 10 million per gram of wash water (control) to 117, 280, and 420 million for each of the successively higher humidities, respectively. Mold populations at the two lower temperatures did not show significant increases after 6 days at any humidity. The first substantial increase was at 70° F. and 50-60% RH. At 70° F. and 80-85% RH, the mold count increased from about 1000 per gram to 600,000; and at 80° F. the count rose sharply at all humidities and with each 1-day longer holding period. Increases in mold populations were accompanied by sharp increases in softening enzyme activity of the cucumber samples.

This work, with amplification in another season, will provide basic information to guide improvement in handling of pickling cucumbers between harvesting and processing, which at times results in considerable economic loss and in poor fresh-pack products for the pickle packer and consumer.

Irradiation on the Microflora of Cucumber Fruit and Blossoms. Investigations were initiated during the 1959 harvest season, in cooperation with the National Pickle Packers Association and the Nuclear Reactor Project of the N. C. Agricultural Experiment Station, to ascertain the effects of irradiation of cucumber fruit and blossoms on the populations and activity of microorganisms responsible for softening enzyme activity in brining.

With 7 samplings of cucumber fruit and 2 of flowers, the initial populations of 8 microbial groups were much higher on the blossoms than on the fruit; but on irradiation in a Cobalt-60 gamma source, the corresponding microbial survival curves indicated that the destruction rates were comparable for both types of material. Of the various microbial groups, the asporogenous bacteria, as represented by the coliform and acid-forming bacteria, were found to be most sensitive to radiation; the aerobic and anaerobic spore-forms were observed to be the most resistant. The yeasts and molds appeared to be second only to bacterial spores in radiation resistance. However, the resistance of molds as a group and of yeasts was considered to be essentially the same. Increasingly higher doses of gamma radiation resulted in correspondingly lower cucumber firmness values as compared to nonirradiated controls. The value of gamma radiation other than as a laboratory working tool remains to be demonstrated. Such radiation may provide a means for attenuating the microflora or sterilizing the surface of cucumbers so that the potential value of pure culture techniques for the brine curing of cucumbers may be demonstrated.

Further cooperative effort was directed to design and construction of a gas-beta radiation facility for surface sterilization of cucumbers. While it is premature to predict the potential potentialities, such treatment may have advantages over gamma radiation as a tool for surface sterilization prior to pure culture fermentation studies. Very little penetration of the cucumber would be expected from such radiation and thus physical and chemical changes in the fruit would be greatly minimized as compared to the effect of gamma rays.

Plans: The major research effort will continue to be directed toward the development of pure culture fermentation techniques for the brine curing of cucumbers for pickles. Advantage will be taken of the availability of facilities at the N. C. Agricultural Experiment Station for the gamma (Cobalt 60) and beta (gas) irradiation of cucumbers to reduce and/or attenuate the microbial flora prior to pure culture inoculation. Studies will be undertaken to determine the most suitable species and strains of lactic acid bacteria for use in pure culture cucumber fermentations; and factors affecting their growth and lactic acid production. Mass inoculation of brined cucumbers with selected species of lactic acid bacteria in the presence of the natural flora will be attempted as a means of controlling cucumber fermentations--preventing softening and bloat formation and improving cure. The pricking of cucumbers with

mechanical devices will also be studied as a means of reducing bloater formation in large cucumbers during brine-curing.

Publications: Filamentous Fungi from Blossoms, Ovaries, and Fruit of Pickling Cucumbers. F. L. Raymond, J. L. Etchells, T. A. Bell, and P. M. Masley. *Mycologia* 51 (4):492-511. 1959.

5. CANNING BY HIGH-TEMPERATURE SHORT TIME PROCEDURES

EU

Problem: Determine the improvement in quality of vegetables canned by high temperature-short time techniques, and the extent of quality retention by storage at refrigerated temperatures.

Program: A contract with Rutgers University, New Brunswick, New Jersey, involving a total expenditure of \$24,092; studies initiated in 1957 and scheduled for completion in, or before, 1961.

Progress: Work on the preparation, refrigeration, and evaluation of canned peas, green beans, corn, asparagus, and tomato juice sterilized by high-temperature, short-time (HTST) techniques were continued under contract at Rutgers University. Flavor evaluations for the five products indicate that the HTST processed samples were all significantly different from conventionally processed samples with the exception of tomato juice. Flavor of the HTST products appears to be "fresher" or "more like the raw product" than the conventionally processed samples. The lustrous appearance of the HTST sterilized products was evident subjectively and was described as a "fresh" appearance. The HTST sterilization process resulted in either greater or equivalent retention of vitamins when compared to the conventionally processed samples. New HTST equipment developed for experimental purposes was limited to one can size and to a low operating speed.

Plans: This project will be continued for a minimum of one more processing season.

Publication: Low Temperature Handling of Sterilized Foods. I. Design of Equipment and Outline of Processed Used. Arnold I. Epstein and C. Olin Ball, *Food Technology* 14, 363-365 (1960).

6. BASIC RESEARCH FOR CANNED VEGETABLES

WU

Problem: The heating requirements for sterilization of low-acid foods are so severe that they limit quality improvement of many vegetable products. The remarkable heat resistance of spores of food spoilage bacteria has never been adequately explained, yet that resistance is the determining factor in commercial processing. In the absence of advanced knowledge, the establishment of process conditions must be based on empirical studies of each product.

Program: A continuing program of basic and applied research on the heat resistance of bacterial spores as it relates to the canning of vegetables is being conducted, involving three professional Federal man-years per year. Contract research on compositional changes in bacterial spores is being conducted at the University of Illinois.

Progress: The Nature of Heat Resistance of Bacterial Spores. A basic requirement of the continuing research on spores and spore resistance is that suitable quantities of viable spores be available and practically free of vegetative cells, cellular debris, and medium particles. A method was developed, using a medium with high manganese level supplemented with Versene (a metal-sequestering compound), for causing consistent, rapid, and abundant sporulation of a Bacillus coagulans strain, thus providing a dependable source of spores for study. Spores obtained by this method had remarkable heat-activation requirements and remarkable thermal resistance--highly suitable for the continuing studies. Considerable progress was made in the use of enzymes in removing vegetative cell debris from spore suspensions. A new system was developed that provided for the first time a relatively simple and effective method of obtaining the required cleanliness in spore suspensions. Viability and thermal resistance were not affected.

A pink coloration, seen occasionally in spores and called "spore blood," was investigated; it appears to be due to two types of metal chelates involving coproporphyrin and dipicolinic acid. Preliminary work toward the objective of localizing dipicolinate and minerals in spores has been completed in the preparation of separated spore coats of Clostridium perfringens (calcium and dipicolinic acid were not detected in such coats), and in obtaining electron micrograph sections of spores to be used for control purposes in following the release of dipicolinic acid by various treatments.

A new concept was postulated to explain the heat-resistance of bacterial spores. Observations that tend to contradict the time-honored hypothesis of an impermeable membrane and anhydrous core in spores are reconciled in the new postulate that allows for a permeable, contractile layer in the spore. Contractive forces squeeze the water from the core maintaining a relatively low water content by continuous exertion of external pressure. It was suggested that the spore cortex may be the contractile layer and that divalent metals, so abundant in spores, may play a key role in the contraction of such a layer.

Survey of Compounds Affecting Lethal Heat Requirements. An empirical survey of the effect of added compounds on the lethal heat requirements for the putrefactive anaerobe 3679 (a selected spore-former used to evaluate sterilization conditions for canning practice) was concluded. In this study, 650 substances were tested and 26 found to reduce by 45 to 85% the heating time required for 90% kill.

Plans: Investigations will continue on the exploration of chemical changes accompanying the lethal heating of spores and on experimental evaluation of the concept developed to account for heat resistance and heat activation of bacterial spores.

Publications: Isolation and Properties of a Subtilin Resistant Strain of *Clostridium botulinum*. L. L. Campbell, Jr. and W. Winiarski. *Applied Microbiology* 7(5):285-288 (1959).

Nisin Sensitivity of *Bacillus coagulans*. L. L. Campbell, Jr. and E. E. Sniff. *Applied Microbiology* 7(5):289-291. 1959.

Preparation of Growth Factors. Patent No. 3,942,977. June 1960. J. C. Lewis, Kosuke Ijichi, and P. A. Thompson.

Production of Growth Stimulating Agents. Patent No. 2,906,622. Sept. 22, 1959. J. C. Lewis.

Substances Screened for Ability to Reduce Thermal Resistance of Bacterial Spores. H. D. Michener, P. A. Thompson, and J. C. Lewis. ARS-74-11, July 1959, WURDD, USDA, Albany, California.

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7. IMPROVED PROCESSING METHODS FOR SOUTHERN PEAS

SU

Problem: In order for vegetables to compete with other food items, it is essential that the quality of processed products be improved and that new easy-to-prepare products be developed.

Progress: Processing of Southern Peas; Maturity Separation. Work continued at the Weslaco laboratory on improving the uniformity of quality in canned packs of Southern peas by separating the raw stock into sizes and fractionating these sizes by brine flotation into green and overmature components. Alcohol-insoluble solids (A.I.S.) determinations are used for measuring the maturity of the different fractions. Data from two lots (one mature and one less mature) of spring-grown peas which had been sized and flotation separated in 3% brine show that a larger percentage of the more mature lot separated into the larger sieve sizes and that the A.I.S. and total solids (T.S.) percentages increased as the size grades and maturity increased. For both lots of peas the large increase in A.I.S. and T.S. of the portions of sieve sizes 2 and 3 shows that the hard, overmature peas which had begun to shrivel were separated through these screens, along with the green immature peas of the same size. Due to greater differences in specific gravity the sized peas could be more effectively separated

in a brine solution than would have been possible without sizing. With the aid of a special pea dyeing technique it was demonstrated that sizing concentrated a greater proportion of insect-damaged peas in the two smaller sizes. Flotation of the several sizes in a 3% brine solution, although it separated mature from immature peas, did not concentrate a high percentage of damaged peas in either the floaters or sinkers.

A spinning attachment was constructed for the Hunter Color Meter which makes possible color notations on nonuniformly colored small vegetables like blackeye peas without blending the sample. This device facilitates ascertaining whether the smaller immature peas or the older mature peas cause the most discoloration in canned products.

Plans: Limited work will be continued to test other brine concentrations in the maturity separation of Blackeye peas; to evaluate the brine separation for another commercial variety of southern pea.

8. IMPROVED PROCESSING METHODS

WU

Problem: The quality of processed vegetables and the economy of their processing have not improved rapidly enough to improve or even maintain their relative position in the American diet, or increase their contribution to export trade.

Program: A continuing program of applied research, involving four professional Federal man0tears per year, is being conducted by WU on the development of new and improved dehydrated and otherwise preserved vegetable products at Albany, California, and in commercial plants in Oregon and California, in cooperation with individual companies in the processing industry.

Progress: Foam-mat Drying: Convenient, instant-preparation dried foods have been responsible for a renaissance of the dehydration industry in recent years. Instant fruit juices, coffee, potatoes, sauces, milk, and baby foods are filling grocery shelves and being enthusiastically received by consumers. The foam-mat drying process is a significant new technology by which all of these products, and more, have been satisfactorily prepared. Over thirty different foods (juices, purees, sauces, and other liquid or semi-liquid foods) have been dried without appreciable quality loss.

In general, foam-mat drying is accomplished by preparing a stable foam of the food to be dried, with a small amount of edible foam stabilizer added for some products. The foam is spread to increase its specific surface and dried in a hot air stream. With hygroscopic or thermoplastic materials, a last stage drying with cool, desiccated air facilitates removal of the product from the drying surface (endless

belt or tray). Fatty monoglycerides, which are approved for food use, have been used as foam stabilizers.

In continuing investigations, foam stabilizers other than monoglycerides, particularly non-fatty types, were tested with considerable success, and improved methods were developed for introducing the foam stabilizers into products to be dried. Continuous foam preparation was accomplished by pumping the food, stabilizer (not needed for all foods), and gas into a high shear mixer.

The drying time for foam-mat drying was reduced from 60 to less than 10 minutes by a new "crater" technique. This involves spreading the product on a perforated tray or belt and blowing craters through the foam to provide larger surface and through-flow of air. This, of course, represents a very significant development concerned with the economy of the process. An extension of these developments to industry practice is being aided by cooperation with companies interested in using the new technology.

One of the instant dried products for which exists an immediate market demand is a good quality tomato powder. Although laboratory methods established the feasibility of such a product by vacuum puff drying, no large-scale successful commercial development of this procedure exists. Investigations are continuing on the effects of variables in the foam-mat drying process on quality of tomato powder. Stability tests on preliminary products have shown improvement and further tests are continuing on improved products.

Dehydrofreezing. Commercial application of dehydrofreezing has not been as rapid as seemed to be warranted by the product quality and cost considerations indicated in past research. However, large commercial orders indicate a major break-through in dehydro-frozen food. Production of peas this year will be between $1\frac{1}{2}$ and 2 million pounds, a substantial part of which will be exported. A large processing plant is under construction for the manufacture of 17 dehydro-frozen baby foods, which have been under market test for the past year. Cooperative processing trials were carried out in Oregon. Large sample quantities of dehydro-frozen peas were produced for trial use in the institutional trade.

This study is substantially complete and further contributions on dehydro-freezing of vegetables will be limited to extending technical advice to interested processors. Substantial trade interest in dehydro-frozen peas during the current year seems to insure a solid commercial interest and continuation of industrial developments.

Freeze Drying. Basic engineering studies on freeze drying of vegetable pieces have been concluded with the finding that drying rate during the latter stages of vacuum freeze drying is limited by the heat

conductivity of the already dried shell. The practical implication of this finding is that very high vacuum systems for freeze-drying operations are not justified because less high vacuum systems will produce maximum drying rates. For effective use of conductive heating in freeze drying, good thermal contact should be maintained between product and heat source.

Quick-Cooking Dry Beans. A quick-cooking product that has the same appearance as dried beans is believed to be one of the keys to improvement in utilization of dry beans. Studies are continuing to develop a new product by a chemical modification of beans that will shorten soaking and cooking times. An experimental cooker was developed to remove opinion and subjective response from data on bean cookability. The device was used to measure a beneficial effect of treating beans with a phosphate solution prior to cooking.

The benefit was reduced when the beans were redried after the treatment and then cooked. The phosphate treatment had a greater effect on bean cotyledons than on seed coats. This led to the development of a new bean product that may be cooked in 20 minutes without prior soaking. The product was developed by treating beans with phosphate solution, removing seed coats, and then redrying. The product is analogous to the familiar split pea; and preliminary evaluations of the "Bean Fillets" were promising.

Intact bean seed coats were found to be very impermeable, and rehydration of dry beans may be largely limited to the flow of water through the small opening in the hylar scar. By producing a pressure differential between the bean interior and the surface of the soak water (by applying external pressure or by a quick reduction of the water temperature) a driving force was created that was useful in placing supplements (e.g. methionine) in the interior of dry beans with a minimum of hydration. This pressure or temperature programming was useful in the incorporation of supplements into beans without undue change in the appearance; and also in the analysis or separation of beans with split seed coats, because only those with such imperfections could imbibe water rapidly during a steadily increasing temperature or decreasing pressure.

Fouling of Heat Transfer Surfaces. This project has been completed. It was undertaken to obtain fundamental data relating to processing conditions and fouling rate of heat transfer surfaces in flash entry evaporators; and to provide a rational basis for designing improved evaporators for fluid foods.

The factors affecting the fouling rate of evaporator surfaces have been identified as surface temperature, concentration of solids in the liquid, and vapor fraction accompanying the liquid. Mass velocity, linear velocity, heat flux and steam or liquid temperatures did not, in themselves, affect fouling rates except through their effects on the three other factors. The effect of surface temperature on fouling

rate could be interpreted in terms of the activation energy of the fouling reaction. For tomato products this energy is consistent with the activation energy of wet protein denaturation. Analysis of the wall deposits after evaporation of tomato, grape, and some synthetic mixtures also suggested that the fouling reaction involved proteins primarily, even when the protein concentration was extremely low.

These basic conclusions lead to several considerations in regard to the design and operation of the evaporators generally. Feed should be preheated to its boiling point at the pressure existing at the entry of the evaporator tube. This avoids the high surface temperature which would exist in a region of high resistance to heat transfer from the wall to the liquid. This high resistance is characteristic of the warming as distinguished from the boiling region.

Concentration must be effected by passing the liquid a number of times through the same or different tubes allowing the vapor to escape between successive passes. This conclusion arises from the fact that fouling increases as the vapor fraction increases. Fouling also increases as concentration increases -- hence, for a large change in concentration per pass, fouling is likely to be severe.

A novel technique was developed during this research. In this technique the stainless steel evaporator tube was itself used as a resistance thermometer. Current flowed lengthwise in the tube while the voltage drops across short sections were measured by means of wires attached to a tube passing out through the steam jacket. When direct current flowed, the voltage drops were proportional to the temperature at the radial center of the tube wall. When audio frequency alternating current flowed, the voltage drops were proportional to the temperature near the outside surface of the metal wall. This effect arises from the decrease in inductive impedance with radius in an annular conductor. Simultaneous observation of these two temperatures in the same region made it possible to calculate the surface temperature and heat flux in that region. This technique seems to offer great promise for research in heat transfer generally.

Some difficulty arose in the operation of the steam injectors used with the flash entry evaporators and this was systematically investigated. Exact design criteria and operating instructions were developed for use of steam injectors for any purpose. The effects of various conditions and designs were observed by means of entry and exit fluid properties. In addition, a glass model was built and high speed motion pictures were taken of its operation. This resulted in data on instability and vibrations. These data were received with great interest by a variety of industries interested in adopting steam injection heating. The factors of heat flux, temperature difference, and vapor fraction have been correlated for the nucleate boiling of water flowing down a steel tube. These are the crucial interrelationships for the design of any vapor generator of the forced circulation type. These data were a necessary

prelude for the study of fouling and may prove to be of great economic value because this information will be useful in the design of nuclear boiling water reactors.

The results obtained in this project offer the first scientific basis for interpretation of fouling phenomena.

Plans: Work will be continued on the development of improved tomato juice powder and quick-cooking and other dry bean products. Extension of research findings to industrial trials will be accomplished by cooperative studies in processing plants, where interest may develop.

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Microscopic Structure and Reconstitution of Vacuum Dried Tomato Powders. R. Reeve, Vern Kaufman, and F. Wong. Food Technol. 13(10):561-566 (1959).

9. TIME-TEMPERATURE TOLERANCE OF FROZEN VEGETABLES

WU

Problem: Frozen foods frequently reach consumers with much of their garden-fresh quality lost because of sub-optimum processing methods and unfavorable time-temperature experience while in market channels between packer and ultimate consumer. Objective methods for measuring quality factors and quality loss are inadequate for industry-wide use.

Program: A continuing program of basic and applied research, involving three professional Federal man-years per year, is being conducted on the nature of quality changes in frozen vegetables, methods for measurement of quality, and effects of processing conditions on quality.

Progress: As a part of a series of detailed investigations on processing modifications that would enhance the stability of stored frozen foods, studies on spinach and cauliflower were made and have been concluded. Six lots of commercially packed frozen spinach representing Savoy and Viroflay varieties and ten lots of cauliflower representing Snowball and March varieties were obtained from East and West Coast producing areas. Samples from each lot were subjected to experiments at 4 to 10 temperature conditions between -20 and 40° F., and evaluated for change with time in flavor; visual color; reflectance color; reduced ascorbic acid; and, for spinach, ratio of chlorophyll to pheophytin; and, for cauliflower, soluble color.

Significant quality deterioration was observed within time and temperature conditions that are known to occur sometimes in the commercial handling of frozen foods. In the temperature range of 0° F. to 25° F., measurable rates of deterioration increased by a multiple of 10 for about each 15° rise in temperature. In comparison with earlier studies on peas and green snap beans, spinach was found to have a chlorophyll deterioration rate ranging up to twice that of peas but only half that of beans. Minor flavor change in spinach could be detected by a trained panel of judges after about four or five months storage at 0° F.; two months at 10° F.; and less than a month at 20° F.

A new analytical procedure was developed for the soluble brown pigment of frozen cauliflower, which was found to reflect the change in product color as this product deteriorated during storage. Color changes in such a white product are more apparent and probably more objectionable than some of the minor flavor and color changes that are detectable by laboratory evaluations and have been reported for the other vegetables studied. Detectable color changes in cauliflower were observed in very short storage periods at temperatures above 0° F. and in less than 4 months at 0° F. Flavor change in cauliflower was not detected until almost a year at zero.

For both spinach and cauliflower the vitamin C activity (measured as reduced ascorbic acid) is substantially higher than of peas or beans.

On the other hand, the loss of this activity during storage is much more significant. Nearly half of the ascorbic acid is lost in a year at 0° F. and the rate of loss doubles for about each 5° F. rise in storage temperature. These rates are nearly ten times those of peas and four to five times those of beans.

Two frozen vegetables, cut corn and French-fried potatoes, which have not yet been studied for the effects of time and temperature on retention of quality, were subjected to preliminary evaluations to determine the possible need for more detailed studies. These products are generally more stable than the ones studied heretofore.

Plans: Further work on the time-temperature tolerance of frozen vegetables will be done only as new problems arise. However, it is anticipated that extension of the information obtained in recent years will require continuing effort.

Publications: Time-Temperature Tolerance of Frozen Foods. XXI. Frozen Peas. M. M. Boggs, W. C. Dietrich, M.D. Nutting, R. Olson, F. E. Lindquest, G. S. Bohart, H. J. Neumann, and H. J. Morris. Food Technol. 14(4):181-185 (1960).

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Research for Better Quality in Frozen Foods. ARS-74-13, Aug. 1959, WURDD, USDA, Albany, California

Taking Product Temperatures in Frozen Food Cases. ARS-74-14, Sept. 1959, WURDD, USDA, Albany, California.

10. FACTORS AFFECTING PROCESSING CHARACTERISTICS OF NEW VARIETIES

WU

Problem: The quality of some processed vegetables is not uniformly high because varieties are often selected on the basis of agronomic characteristics with insufficient heed paid to processing characteristics. The proportion of vegetables marketed in processed form is constantly increasing and, therefore, it is important to consider processing as well as agronomic factors in their selection.

Program: A continuing long-term program of applied research on the suitability of new and established varieties of vegetables for processing is being carried on at Prosser and Puyallup, Washington in cooperation with the Washington State Agricultural Experiment Station and by SU's laboratory at Weslaco, Texas in cooperation with the Texas Agricultural Experiment Station and vegetable growing and processing industries of the Lower Rio Grande Valley. Further work on evaluation of cucumber varieties for pickling is carried on by the Raleigh Laboratory in cooperation with State experiment stations and industry in the South, East, and Great Lakes area, and with the National Pickle Packers Association. Total effort involves about two professional Federal man-years annually.

In addition, studies of adventitious microbial flora within the tissues of raw vegetables and their effects on processing and preservation, as a basis for the development of products of superior quality, are being conducted in Rehovot, Israel, supported by funds under Public Law 480.

Progress: Processing Quality of New Vegetable Varieties. Cooperation is continuing with the Washington State Agricultural Experiment Station at Puyallup to evaluate the processing character of vegetable varieties under cultural trials at the field stations in the State. Thirty-nine varieties of green peas were processed and evaluated. In one series of 19, eight showed better color and three better flavor than the Thomas Laxton variety used as a standard. Twelve varieties of green and wax snap beans were processed and evaluated. One strain rated ahead of FM-1 and Asgrow 228 Blue Lake strains, which are considered industry standards of excellence. Six varieties of sweet corn were tested for processing quality and a special study of them was made as to the yield of corn cut from the cob in relation to maturity at the time of harvest.

It is the nature of this work to continue in cooperation with plant breeders, helping make the selections that will lead to improved varieties. The contribution of Utilization Research is to ascertain the processing characteristics, as horticulturalists make selections based on agronomic characteristics. It is significant that a number of selections of peas and snap beans of improved agronomic quality showed equal or better color and flavor than varieties upon which the industry is now dependent. A critical factor in the processing

of sweet corn is the selection of the optimum harvest date. This then is one of the evaluations that is a part of the continuing studies on the processing characteristics of this vegetable.

Microbial Flora in Raw Vegetables. In studies of bacterial content of freshly picked tomatoes being conducted in Israel, the amounts differed according to origin of the raw material. It appeared that the stem was the point of entry. Also analyzed were grapes, cucumbers, apples, and melons. Storage of surface-sterilized fruits under anaerobic conditions appeared to foster multiplication of bacteria below the fruit surface. Results now available indicate that bacteria are quite regularly present in the tissue of normal healthy tomatoes, both in green and red ripe fruits. This fact had not been established previously. The most common bacterial type found has been a motile rod belonging to the genus Pseudomonas.

Progress: Texas Green Beans for Processing. Completion by the Weslaco laboratory of cooperative processing evaluation tests extending over 6 seasons on 18 varieties and 7 strains of green beans has provided new information to guide selection of more desirable raw stock for canners in the Lower Rio Grande Valley area. All the wanted characteristics have not so far been found in any single variety; but Topcrop, Pearl-green and Topmost, can be recommended for commercial production.

A third season's evaluation of the effect of row spacing of green beans on processed quality revealed no significant differences other than in acre yield.

Beets for Canning in the Lower Rio Grande Valley Area. In further cooperative studies, canning tests were initiated to determine quality differences in 20 varieties and selections of canning type beets from 5 seed sources. Evaluations were made for yield, size, black spot (scab) percentage, pH, percent acid as citric, refractive index, and percentage loss in canning. Findings await later evaluation of the canned products for pH, acid, Brix, color, and flavor.

Characteristics Affecting Pickling Quality of Cucumbers. Cooperation has continued with the Arkansas Agricultural Experiment Station and the pickle industry in the Southwest in studying the processing of new varieties of cucumbers for pickling purposes. The findings indicate that Arkansas No. 1 is the most advanced line so far and is, in general, superior in color, shape, and earliness of harvest to the now widely used Model variety. Arkansas No. 1 processes and finishes in a manner highly acceptable to the industry.

In the evaluations for the 1959 season at the Brown Miller plant in Texarkana, 175 bag-lots of cucumbers in brine were examined. These

represented 3 pickings each of 21 experimental varieties and controls grown at Fayetteville, Arkansas, and 34 lines and controls grown at the Hope Branch Station. Each bag lot was rated by a panel of five experienced brine-stock judges as to color, shape, firmness, and acceptability for commercial use. Also, the large-sized cucumbers (No. 3's) from each lot were cut to determine bloater (hollow) content; and 10 small-sized cucumbers (No. 1's) were pressure tested for firmness. In addition, brine-stock samples from 10 commercial vats of MR-17 variety, grown in West Texas, were evaluated, as well as 2 samples of Arkansas No. 1 and Model varieties grown in some quantity on the Shelton Farm near Texarkana.

In further cooperation with the Research Committee of the National Pickle Packers Association, 2 pickings each of 14 cucumber lines, grown in Connecticut and brined in New York City were evaluated in March for commercial brine-stock purposes. During the same month, similar cooperation was rendered the Michigan Agricultural Experiment Station in respect to 25 cucumber lines. Two of the Michigan lines, both showing resistance to scab and mosaic, appeared very promising. Detailed findings of the two latter evaluation studies await interpretation of the compiled data.

Plans: Cooperative work with the Washington Agricultural State Experiment Station on evaluation of vegetable varieties for processing characteristics will continue, as will the studies on microbiology of raw vegetable tissue in Israel.

Cooperative effort in evaluation of Lower Rio Grande Valley vegetables for processing characteristics and of cucumbers for pickling purposes will continue as new varieties and strains are developed and put under test.

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III. HOME ECONOMICS RESEARCH

1. QUALITY OF VEGETABLES

HN

Problem: A problem of food users is to select well and to make the best use of the vegetables available in the market. In order to do this, information is needed on the nutritive values of the different kinds and forms of vegetables available, how to preserve their valuable qualities before and during cooking and how to prepare and serve them so as to be attractive and acceptable.

Program: A continuing long-term basic laboratory program is underway at Beltsville, Maryland to ascertain the nutritive value and edible quality of selected vegetables as commonly prepared for the table. Vegetables selected for study are those now important in diets, or potentially important as sources of needed nutrients, and those most affected by nutrient losses and quality changes during cooking. Knowledge of the relation between eating quality and the physico-chemical changes that take place during cooking is sought to aid in the selection of cooking procedures for optimum quality under varying circumstances. Part of this research is cooperative with the Agricultural Marketing Service. At present about 4 professional Federal man years annually is given to this work.

Progress: Frozen Vegetables. Concern for quality maintenance of frozen vegetables in the marketing channels and in households prior to ultimate use led to studies on the quality of frozen vegetables both as received from the local retail market and after cooking. Brussels sprouts, broccoli spears, cut green beans, green peas, green lima beans, and leaf spinach were studied. Selected brands of the vegetables were purchased from designated stores, and each brand-store combination was replicated four times for four consecutive seasons. For comparison, samples of frozen vegetables were obtained directly from a Maryland processor and fresh vegetables from the local market.

Criteria of quality used in uncooked green vegetables were the ratio of oxidized to reduced ascorbic acid, percentage of chlorophyll conversion to pheophytin, and changes in reflected color. For the cooked vegetables, panel flavor scores proved to be a sensitive quality index.

Although there was considerable variation in quality of all vegetables investigated, the number of distinctly low quality samples was small. The means values for quality factors investigated in samples of frozen vegetables from the retail market were in most cases similar to those for samples obtained directly from the one processor. Mean values for ascorbic acid content of frozen vegetables from the retail market were in most cases similar to those for samples obtained directly from the one processor. Mean values for ascorbic acid content of frozen vegetables as purchased were usually lower than for fresh. The ratio of oxidized to reduced ascorbic acid and the percentage of chlorophyll converted to pheophytin were usually higher for frozen vegetables than for fresh.

Electronic Cooking. The effect of microwave cooking on palatability and nutrient content of fresh and frozen broccoli was investigated at Beltsville, Maryland. The time for cooking broccoli to optimum tenderness electronically was found to be about 6 minutes for 1 pound of fresh broccoli compared with 13 minutes by boiling. Frozen broccoli took longer to cook electronically -- 13 minutes for 20 ounces of frozen broccoli compared with 11 minutes by boiling. Cooking broccoli in the electronic range took about 0.06 kilowatt-hour of electricity per minute; boiling, about 0.024 kilowatt-hour per minute.

Flavor of broccoli cooked to optimum texture of stems by microwave and by boiling was estimated to be about the same. Color retention in fresh broccoli cooked by microwave was slightly better than in that cooked by boiling; the differences in color of frozen broccoli cooked by the two methods were inconclusive. The ascorbic acid retentions in fresh and frozen broccoli cooked to optimum texture were estimated as higher in that cooked by microwave than in that cooked by boiling. There were no measurable losses in carotene content of fresh and frozen broccoli cooked by microwave.

Plans: Laboratory work on the quality of fresh, frozen, and canned vegetables has been completed and reports of this research are in preparation. The results will be reviewed to determine which direction the work should take, if extension seems justifiable within the funds available.

Publications: Palatability and Nutritive Value of Frozen Broccoli. J. P. Sweeney, G. L. Gilpin, M. E. Martin, and E. H. Dawson. Amer. Dietetic Association Journal 36 (2): 122-128, February 1960.

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Factors Affecting the Ascorbic Acid and Carotene Content of Broccoli. M. E. Martin, J. P. Sweeney, G. L. Gilpin and V. J. Chapman. Agr. and Food Chem. Jour. 8 (5): Sept.-Oct. 1960.

Home Care of Purchased Frozen Foods. Home and Garden Bulletin No. 69. 8 pages, July 1960.

2. AGRICULTURAL CHEMICALS AND FOOD FLAVOR

HN

Problem: To assure that agricultural and food processing chemicals cause no undesirable changes in flavor or other consumer qualities of foods which might interfere with their acceptance, palatability as well as wholesomeness must be ascertained in the developmental stages before the chemicals are marketed for use.

Program: HN maintains at Beltsville a continuing program cooperative with divisions of Farm Research to investigate the effect of use of agricultural chemicals on flavor of commodities as prepared for eating. As sample size and variety permit, the Division also makes studies to improve methods of conducting palatability evaluation. About 2 professional Federal man years annually are involved in HN.

Progress: The flavor of foods exposed to certain agricultural chemicals in their production has been investigated in continued cooperation among HN, CR, ENT and with the Northeastern Regional Research Project, NE-15.

Research in seven State Experiment Stations and the United States Department of Agriculture, coordinated through the Northeast Regional Research Project (NE-15), sought to determine the effect of insecticides and fungicides on the flavor quality of fruits and vegetables. During six years, the research involved 36 single insecticides, 11 single fungicides, and 29 combinations of insecticides or fungicides used in various dosage rates on 25 vegetables.

Single insecticides inducing poor flavor quality in about 50 percent of the samples were BHC (benzene hexachloride), lindane, and toxaphene; and, in a smaller percentage of samples, endrin and malathion. When used singly PCNB (pentachloronitrobenzene) was the only fungicide that resulted in poor flavor quality. Combinations of pesticides tending to induce unfavorable qualities included toxaphene, sevin, DDT, malathion, captan, and thiram. Toxaphene treatments used either singly or in combinations which induced poor flavor quality were dosages greater than needed for control in the area where the crop was grown.

Pesticides giving no ill effects on flavor when used singly were chlordane, DDT, dibrom, dilan, dimethoate, heptachlor, phosphamidon, sevin, thiodan, trithion, Bordeaux, tribasic copper, and zineb. When used in combinations, diazinon, lead arsenate, and glyodin did not influence flavor adversely.

Plans: Cooperative testing for palatability and methodological studies of flavor evaluation will be continued as opportunity permits. Increased funds available to HN for 1960-61 will be used at first to initiate some basic studies of methodology of panel judging to help sharpen the acuity of taste testing, or other evaluations of effects of pesticides on quality. For example, problems of appearance of toughness or firmness resulting in uneven cooking in exposed vegetables needs to be investigated.

IV. MARKETING RESEARCH

A. Market Potentials, Preferences, and Development

1. NEW AND IMPROVED MERCHANDISING METHODS

MD

Problem: A continuing need exists to encourage improvements in the retail merchandising of vegetables and vegetable products through better packaging, pricing, display and other measures that will enhance their competitive position in the market place and attract the shoppers' attention.

Program: The program is one of long-term marketing research involving field studies and analyses of merchandising methods on a national, regional, or local basis depending on the requirements of the problem being considered. In many instances work is undertaken in cooperation with food stores as well as agricultural groups. Less than one professional Federal man-year is required.

Progress: Retailer Use of Merchandising Aids Provided by Agricultural Groups. A study is under way to determine (1) the extent of use by food retailers of in-store promotional materials provided by agricultural groups, (2) policy of retailers regarding use, (3) characteristics desired by retailers in in-store promotional materials, and (4) requirements for acceptance of these materials. Extent of use will be observed in a national sample of approximately 1,800 stores, and interviews will be conducted with appropriate retail and wholesale trade merchandising officials in ten major metropolitan areas to obtain information on desirable characteristics and features required for acceptance of these materials.

Plans: Collection of data for the study of extent of use and factors influencing the use of in-store promotional materials is planned for early 1961. Tabulation and analysis of the data are scheduled for completion by mid-1961.

2. CONSUMER PURCHASES OF CANNED VEGETABLES

MD

Problem: Growers and processors need information on seasonal changes in household purchases of canned corn, snap beans, and green peas, and the relation of selected consumer characteristics to given levels of purchases as a basis for improving the effectiveness of distribution and promotional efforts, and expanding markets.

Program: This was a short-term program designed to provide growers and processors with an analysis of the household market for selected canned vegetables on both a national and regional basis. Collection of data was done by the Market Research Corporation of America

under contract with the Department. The work was carried on in cooperation with the National Cannery Association. Less than one professional man-year annually was involved.

Progress: Findings indicate that 11 to 16 percent more households purchased the canned vegetables included in the study during the peak winter months than in August, a low month. Study showed wide variations among products in percentage of households purchasing during year, frequency of purchase, average quantities purchased, regional purchase rates, and money paid. Heavy buyers, purchasing an equivalent of 9 (No. 303) cans or more during the year, accounted for approximately 70 percent of total purchases of these canned vegetables. About 1 of 5 families were heavy buyers.

Plans: In view of findings concerning concentration of purchases in the hands of relatively few heavy buyers, consideration is being given to obtaining a re-run of basic data which will provide information as to the characteristics of heavy, medium and light buyers, such as income, size of household, age and outside working status of housewife, city size and other factors pertinent to market evaluation.

Publications: Household Market for Canned Fruits and Vegetables. Kenneth E. Anderson and Russell L. Hawes. Agricultural Marketing, August 1960.

The Household Market for Selected Canned Fruits and Vegetables. Kenneth E. Anderson and Russell L. Hawes. Marketing Research Report No. 427, September 1960.

B. Measurement and Evaluation of Market Quality

3. MEASUREMENT OF MARKET QUALITY FACTORS

MQ

Problem: New and improved methods and techniques of identifying and measuring quality factors in vegetables are needed to provide better inspection, sorting, grading and standardization of these commodities.

Program: This continuing program of applied and basic research is conducted at Beltsville, Maryland and in cooperation with the Maryland Agricultural Experiment Station, and involves about two professional Federal man-years annually.

Progress: Evaluation of the Quality of Processed Tomato Products and Raw Tomatoes for Processing. As a result of the encouraging response to the 1959 demonstrations of the modified inspection procedure and the raw tomato juice Colorimeter, seven Colorimeters were purchased by tomato products manufacturers and research institutions for use in 1960. Tile standards for color were developed for control of the new instruments when used in official inspection by the

Department. Suggestions for important improvements of the prototype instrument were made by research personnel and incorporated in the new instruments.

Results of preliminary tests on processed juice color evaluation showed that the Tomato Color Index, for samples of tomato juice processed under a standardized technique, correlated highly with visual ranking of human observers. The tomato juice samples were prepared from 12 different varieties and breeding lines. The panelists, however, ranked the samples on the basis of color alone rather than on varietal quality.

On the basis of these preliminary results, the new Tomato Colorimeter, which calculates the Tomato Color Index automatically, seems promising as a dual-purpose instrument for evaluating both raw tomato juice and processed tomato product color.

A study was also carried out during the 1960 tomato season, in cooperation with a manufacturer of tomato products, on the color changes associated with processing raw tomato puree into finished tomato products. Also a comparison was made of the percentage non-usable portion of growers loads, as determined by grading a representative sample of raw tomato stock by the new modified inspection procedure, with total actual waste for each load. These data have not been analyzed.

Quality Evaluation of Sweetpotatoes. A new instrument, the Firm-O-Meter, was tested for its applicability to measurement of firmness of canned, whole sweetpotatoes. This simple device appears applicable, particularly because it shows up variation among individual roots in the same can.

An experimental color chart was developed to provide uniform standards for sweetpotato-skin color. This chart contains squares of color which are direct matches of the skin colors of a series of roots selected to provide the normal range of color in sweetpotatoes.

Nineteen varieties and breeding lines were evaluated for processing suitability. Lines HM 288, B 6919, M 97-4, L-3-77, and the established varieties Copperskin Gold Rush, Porto Rico I, and Jersey Orange received highest scores for eating quality and HM 288, HM 434, 6-3-118, B 6716, and L-3-77 highest scores for appearance. Fibrous texture, bland flavor, and lack of uniformity of color were major causes of low scores. A selection (L-3-77) previously reported as showing good quality has been released as "Centennial."

Quality Measurement of Canned Southern Peas. The objective of this work, conducted in cooperation with the Maryland Agricultural Experiment Station, was to develop objective methods for evaluating the "character" factor as related to the grading of canned southern peas.

Three varieties of southern peas, California Black-Eye, Dixie Lee and Early Ramshorn were harvested at eight stages of maturation, and processed under different blanching and cooking times and temperatures. Official USDA grades for character were obtained in addition to the following objective determinations: Total solids (raw product only); texture by the use of the Maryland shear press; size, by weight and volume of 100 seeds; drained weight; liquor quantity; alcohol insoluble solids (AIS); and pectin as galacturonic acid. The stage of maturation, as indicated by the harvest date, had a major influence on the grade for character. Of the objective methods used, shear press values showed the best general relationship to character, with a correlation coefficient of -0.82. The AIS test showed the next best relationship. Total solids of the raw produce, a frequently used index of maturation, did not show particular promise.

Dixie Lee received a significantly lower average score for character and was much less succulent than the other two varieties, as indicated by higher average shear press readings.

Pectin content increased with advancing maturation, but in the canned samples was affected by processing temperature and time.

Plans: The tomato work will be continued with emphasis on relating objective measurement of raw tomato color with the color of the processed products. If arrangements can be made, the application of newly developed objective color evaluation techniques of raw tomatoes will be tested in California. The sweetpotato work will be continued, to develop information on the relationships of Firm-O-Meter readings to firmness of canned sweetpotatoes. The sweetpotato-skin color chart will be tested further and an attempt will be made to develop a color chart for internal flesh color. The southern pea work will be continued with emphasis on commercially canned samples.

Publications: Derivation of a New Formula for Computing Raw Tomato Juice Color from Objective Color Measurement. John N. Yeatman, Arthur P. Sidwell, and Karl H. Norris. Food Technology, 14(1):16-20, January, 1960.

Direct-reading Tomato Colorimeter. Richard S. Hunter and John N. Yeatman, Processed Paper Presented at Annual Convention, Optical Society of America, Ottawa, Canada, October 3-10, 1959.

C. Product Protection During Marketing

4. POST-HARVEST PHYSIOLOGY AND STORAGE

MQ

Problem: Losses of vegetables occur during storage and in the marketing channels through chilling injury, wilting, aging and flavor and color changes. Basic research is needed to determine causes and develop controls for these disorders.

Program: A long range program, with emphasis on physiological studies or environmental response. This work conducted at Beltsville, Maryland, and at field laboratories in Fresno, California, Harlingen, Texas, and New York City involves about 3 Federal professional man-years annually, plus contract work on seed packaging at Iowa State University, Ames, Iowa. Funds for the study of handling tomatoes in the Navy supply system were furnished by the U. S. Navy.

Progress: Tomatoes for Navy Supply. A study was undertaken to determine the best method of ripening and storing tomatoes to provide good quality fruit after 10-12 days ripening and for a period of 2-3 weeks thereafter. Six classes of tomatoes, showing varying degrees of color, were ripened at 58°, 65°, and 70°F. Full, red color was obtained in 6-8 days at 70°, in from 8 to 12 days at 65°, and from 8 days with the most mature class to 10-12 days for the other five classes at 58°. Fruit ripened at 70° and 65° developed better red color than those ripened at 58°. The intensity of red in fully ripened tomatoes decreased somewhat when fruit was held 3 weeks at 32° or 35°. Green tomatoes which colored slowly at suitable ripening temperatures did not develop as good a red color as tomatoes that colored rapidly. Changes in firmness of tomatoes during ripening and storage were determined objectively. Firmness of the fruit always decreased during ripening. It also decreased during storage at low temperature after ripening. Fully ripened tomatoes were generally still firm enough for use after 20-25 days storage at 32° or 35°F., provided they were used directly from storage. Mature green tomatoes ripened at 58°F. were firmer after full color was developed than similar fruit ripened at 65°.

Ripening of Tomatoes in Modified Atmospheres. Tests were initiated to observe the effects of controlled atmospheres on ripening of tomatoes. Turning-stage tomatoes were placed in atmospheres of 0, 5, and 10 percent CO₂ in combination with 3, 10, and 21 percent O₂. After 4 weeks in the CA chambers at temperatures of 45° and 55°F., tomatoes were held an additional week in air in a 70° room. Color development was progressively retarded as the CO₂ concentration was increased and as the O₂ concentration decreased. For example, the 10 percent CO₂ and 3 percent O₂ atmosphere retarded tomato coloring more than other treatments. No off flavors were discernible in tomatoes from any of the CA chambers.

Work to improve the handling methods and flavor of storage-ripened tomatoes was continued by making quantitative determinations of carbon dioxide and ethylene production at both optimum and unfavorable storage temperatures. Carbon dioxide and ethylene production increased with temperature between 35° and 77°F. Above 77° carbon dioxide output was more or less unchanged whereas ethylene production was suppressed. At 90° ethylene production was at a low rate and the fruit developed a yellow color. Upon transfer of the yellow fruit to 77°, ethylene production increased and the red color appeared. Tomato fruits, sufficiently chilled at 35° so as to prevent normal ripening, produced relatively high amounts of ethylene. Apparently, the failure of chilled fruits to ripen properly is not caused by a lack of ethylene.

Physiological Studies on Sweetpotatoes. Comparative physiological and enzymatic studies were made on tissue slices and cellular fractions of chilled and non-chilled sweetpotatoes to determine the metabolic cause of chilling injury. The chilled tissue slices and the particles obtained by centrifugation from the chilled cellular fractions were found to color a redox dye in the presence of certain organic acids at a faster rate than comparable slices and fractions from non-chilled roots. This difference in rate continued until the chilled sweetpotatoes decayed after 10 to 12 weeks of storage at 45°F. This difference appears to result from an impairment, caused by the chilling, in the containing membranes of the cell which permits more rapid interchange of reactants. No differences in the activities of several enzyme systems important in respiration were found between chilled and non-chilled sweetpotatoes.

Studies with small particles (mitochondria) from the cells of sweetpotatoes show that other important respiratory enzymes besides cytochrome C and cytochrome a_3 are present in these particles. By using a double beam recording spectrophotometer, absorption bands were detected that indicate the presence of cytochrome C_1 , cytochrome b_7 and cytochrome b in the mitochondria preparations. The addition of the enzyme inhibitor, antimycin A, to the preparations blocked the connecting pathway of these respiratory enzymes and caused an increase in the absorption at one specific band (563 mμ). Other changes in the absorption bands can be shown by adding oxidizing or reducing substances to the mitochondria. The objective here is not only to determine all the components involved in respiration, but also to determine the factors involved in the regulation of respiration in terms of alternate pathways of electron transport, especially as it relates to aging and senescence.

Senescence Inhibition. A new senescence inhibitor, N⁶-benzyladenine (SD-4901 Shell Development Company) was applied to harvested asparagus to determine its effect on deterioration rate. Neither retention of green color nor fiber development was affected by 15 minute dips in the material (0, 10, or 25 ppm concentration) before

holding 5 days at 59°F. or 2 weeks at 33° followed by 2-1/2 days at 59°. Similar results were obtained when the cut ends of the spears were set in solutions of 0, 10, or 25 ppm SD 4901 for 5 days at 59° or 2 weeks at 33° and then held an additional 2-1/2 days at 59° out of the solutions. After the latter holding period, the tips of the spears showed low-temperature injury and soft rot. Injuries were most prevalent and severe in the water check (93 percent), least in those in the 25 ppm solution and in the dry checks held in a humidified air stream (58 and 52 percent respectively), and intermediate in the 10 ppm solution (71 percent). This suggests that SD-4901 partially suppresses the symptoms of these disorders.

Yellowing of the wrapper leaves is one of the first signs of deterioration in lettuce. SD-4901 was sprayed on lettuce immediately before harvest (10 ppm at a rate of 115 gallons per acre). After 8 days at 37°F., no discernible differences existed between the color of the treated and control lots. However, after an additional day at 70°, the treated heads were slightly greener, and after 4 days at 70°, the treated lots were considerably greener than the checks. The effect was confined to the wrapper leaves, and no difference in marketable weight or decay was noted. Treatment partially counteracted the greater rate of yellowing of hard as compared to firm heads.

Respiration Rates and Ethylene Treatment of Honeydew Melons. Respiration rate measurements of Texas vegetables were continued on a limited scale. Calculated amounts of heat produced (in b.t.u. per ton per 24 hours) by honeydew melons were 6,800 at 90°F., 6,600 at 80°, 5,600 at 70°, 3,100 at 60°, 1,600 at 50°, and 800 at 40°. Respiration rates at 80° or 90° were more than doubled by ethylene gas used at the rate of 12.5 cubic feet per rail car. These rates fell to previous levels in approximately 12 hours after removal of the melons from the gas.

The tests indicate the desirability of gassing honeydew melons at 80°F. rather than the 90° and higher temperatures now used in Texas. A temperature of 80° is easily obtained at night, accompanied by a desirable high relative humidity. Gassing at this lower temperature would provide increased protection against stem and decay caused by high-temperature fusarium species. The results also indicate that better utilization of bunker ice would result if initial icing was delayed for 12 hours after gassing.

Radish Cracking. Studies were continued with three varieties of radishes to see if hydrocooling or packaging increased external cracking. Hydrocooling for 10 minutes in 32-35°F. water caused no new cracks nor did it elongate existing cracks. After 5 days at 50° in polyethylene bags, there was no difference in cracking between hydrocooled and non-hydrocooled lots.

Storage of Seeds. Data on 18-months storage of packaged seeds have been obtained in work done under contract by the Iowa State University.

Eighteen-months storage has indicated differential results under conditions of severe stress to the seeds. Germination of seeds of onion and cabbage was reduced to zero when sealed in metal cans and stored at 110°F. with 7 percent moisture content. Cabbage seed sealed in metal cans and stored at 110°F. with 5 percent initial moisture also was nonviable, while onion, was only slightly reduced in germination under the same conditions. All seeds in metal cans stored at 110°F. with 3 percent initial moisture are surviving moderately well. Data on the second year of storage are now being accumulated.

At high humidity, 85-95 percent, (50°F. storage temperature) the packaging materials show decided differential permeability to moisture vapor. Seeds in cloth and 40% Kraft quickly reached a high equilibrium moisture with loss of germinability. Slower increases of seed moisture occurred in cellophane and polyethylene-paper laminated bags and seed viability declined at a slower rate. Of the materials used polyester and polyethylene bags provided the best protection.

Plans: Studies on the cracking of radishes have been completed. Work will continue on the comparison of subjective and objective determination of color and firmness of tomatoes as influenced by ripening conditions. If funds are available from the Navy, the storage of cucumbers, green onions, radishes, and cauliflower in the Naval supply system will be studied. Work on basic physiological and biochemical problems concerned with chilling, aging, and metabolic processes is being strengthened in the Post-Harvest Pioneering Research Laboratory.

Publications: Salvaging Tomatoes from Frozen Vines.
L. P. McColloch. USDA Marketing Research Report No. 423. November 1960.

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Seeds and Packaging Materials. Duane Isley and L. N. Bass. Proceedings, 14th Hybrid Corn Industry Research Conference of American Seed Trade Association. pp. 101-110. 1959.

Cabbage Celery Lettuce and Tomatoes - Laboratory Tests of Storage Methods. C. S. Parsons, L. P. McColloch, and R. C. Wright. USDA Marketing Research Report No. 402. June 1960.

Effects of Temperature and Packaging on the Quality of Stored Cabbage. C. S. Parsons. Proceedings, Am. Soc. Hort. Sci. 74: 616-621. 1959.

Effect of Temperature, Packaging and Sprinkling on the Quality of Stored Celery. C. S. Parsons. Proceedings, Soc. Hort. Sci. 75: 463-469. 1960.

Ethylene Production by Tomato and Apple Fruits. D. F. Meigh, K. H. Norris, C. C. Craft, and M. Lieberman. Nature 186 (4728). 902-903. June 1960.

5. POST-HARVEST DISEASES

MQ

Problem: Wastage caused by fungal and bacterial rots occurs at each stage of marketing and causes serious economic and nutritive losses. Identification, mode of action and practical control methods for decay organisms are important needs.

Program: A continuing program of research in mycology, microbiology, and plant pathology at Beltsville, and in field and market laboratories in Orlando, Florida; Harlingen, Texas; Fresno, California; East Lansing, Michigan; Raleigh, North Carolina; New York City; and Chicago, Illinois involving approximately 3 Federal man-years annually. The work at Raleigh and East Lansing is conducted cooperatively with the North Carolina and Michigan Agricultural Experiment Stations.

Progress: Sweetpotato Decay Control. Soft and black rot were controlled with warm solutions of less than 0.5 percent Dow A when applied upon removal of sweetpotatoes from storage. Higher concentrations (0.5 to 1.0%) were needed for cold solutions. Of 12 materials tried, sodium sulfite showed the best control of discoloration caused by Dow A on skinned areas of roots. Sodium sulfite, buffered to the proper pH, was satisfactorily incorporated into several commercial formulations of Dow A, but caused flocculation of some wax formulations. The sodium sulfite had no effect upon the control of soft or black rots by Dow A and used without Dow A had no fungicidal effect.

Black Leaf Speck of Cabbage. Samples of freshly-harvested cabbage and late, stored cabbage were obtained either on the New York City market or directly from local growers. The varieties used included Danish Ball Head, Penn State Flat Dutch and Enkhiusen Glory. Holding tests at temperatures ranging from 35° to 70°F showed that the most severe black leaf speck development was at the lowest temperature, whereas no symptoms developed at 70°F. Holding

cabbage under modified atmosphere with low oxygen plus high carbon dioxide air concentrations or at relative humidities of from 50 to 100 percent had no apparent effect on the development of black leaf speck. Detached leaves developed black leaf speck at the end of one week at 35°F and the amount of the specking increased with time. Whole heads of cabbage required at least 4 weeks to show symptoms of the disorder. Culture studies gave no evidence that either bacteria or fungi were involved in black leaf speck.

Watermelon Diseases. Phytophthora rot was serious particularly in shipments of the Peacock variety from Mexico. Black rot continues to be a severe disease of watermelons, principally Charleston Gray from Florida and Georgia. Decay due to Sclerotium rot was apparently on the increase. Preliminary studies show all these decays can infect the host in the absence of wounds.

Black Spot of Radishes. It was demonstrated that the black spot disease of radish was caused by a single species of bacterium. Most inoculation by the causal bacterium occurs during the washing, sizing and grading operations of packaging radishes in plastic bags. The precooling operation alone as commercially used does not reduce the spotting enough to be an effective control measure. Less than 5 ppm of chlorine is effective in killing the causal bacterium under laboratory conditions.

Tomato Waxy Blister. Work was continued to determine the cause of tomato fruit tumor (waxy blister), a disorder which develops occasionally in Texas on fall grown mature-green tomatoes. In past years, fruit tumors have been produced consistently in the laboratory by subjecting fruit of the Rutgers and Pearson varieties to temperatures below 50°F. for several days followed by bruising and holding at 70° and higher. This spring, plants of the Rio Grande variety, growing in pots, were exposed to 40° for 20, 40, and 70-hour periods, after which the fruits were picked, bruised and held at 68°. No fruit tumors resulted, indicating a possible varietal effect.

Russet-Spotting in Head Lettuce. Lettuce exposed to field temperatures of about 84°F. or higher a few weeks before harvest showed more russet spotting when held 7 days at 41°F. than lettuce not so exposed, confirming observations made in the previous year.

Ethylene in very low concentrations increased the severity of russet spotting. Heads exposed to 0.025, 0.05, 0.25, and 0.5 ppm ethylene for 10 days at 37°F. showed more russetting than the controls. There was no difference between the controls and heads treated with 0.0025 or 0.005 ppm, respectively.

The respiration rate (oxygen consumption) at 68°F. of discs of vein tissue from heads previously exposed for one week to 10 ppm

ethylene at 37°F. was significantly higher than that of the non-ethylene-treated controls. The heads exposed to ethylene also showed more russetting than the controls.

Deterioration of Onions in Market Channels. A shipment of New York-grown onions from the 1959 crop was followed through the marketing channels. The results show that bruising was negligible at all stages of marketing and occurred mostly after 5 days display at retail. In general, very little decay was present during marketing. After additional holding for 7 days at 70°F., decay averaged 1.5 percent in samples from the receiver's warehouse, 2.1 percent in retail store samples (on display). Most of the decay was due to bacterial soft rot and gray mold rot.

Microbiological Studies With Dry Beans. Studies were continued to determine the fungi responsible for deterioration of dry beans during storage. Freshly harvested beans yielded primarily "field" fungi. Fungi isolated during the later part of the storage season were dominantly storage fungi (Aspergillus and Penicillium spp). Studies were initiated to develop a more suitable method for obtaining sterile beans from intact pods gathered in the field. The availability of such material is extremely important for pure culture studies.

Observations on fungi development in several commercial storages were made throughout the storage season.

Isolation and Identification of Organisms. Further studies with Pseudomonas marginalis, the cause of a soft rot of head lettuce and other vegetables, show that it does not produce pyocyanin in culture media, has little or no growth at 98°F and above, and produces pectolytic enzymes in culture. These and other characteristics serve to differentiate it from P. aeruginosa which is not considered to be a plant pathogen.

Parsnips showing light-brown to brown blemishes circularly on roots were received from a prepackaging house in January 1960. Records showed the parsnips were sound before being placed in storage in the fall of 1959. Isolations from affected areas yielded pure cultures of Itersonilia perplexans. This fungus, belonging to the Basidiomycetes, has been isolated from Rhododendron, Osmunda, and Potentilla in Japan, from chrysanthemum in Minnesota, and from parsnip in New York State.

Plans: Practical methods of applying Dow A to sweetpotatoes will be investigated and other promising new chemicals will be tested. Studies on the isolation and identification of the fungus flora of dry beans in storage and the organisms causing black spot of radishes and Itersonilia disease of parsnips will be continued. The relation of ethylene and vacuum cooling to russet spotting of lettuce will be studied further. The causes of black leaf speck of cabbage, waxy

blister of tomatoes, the relation of temperature to decay of cucurbits caused by *Phytophthora*, *Mycosphaerella*, and *Sclerotium* will be studied.

Publications: Relation of Internal Gas Content and Respiration to Keeping Quality of Porto Rico Sweetpotatoes. L. J. Kushman, AMS, and M. T. Deonier, ARS. Proceedings Am. Soc. Hort. Sci. 74: 622-641. 1959.

The Effect of Pre-Sprouting and Type of Bed on the Early Production of Sweetpotato Plants. M. T. Deonier, ARS, and L. J. Kushman, AMS, Proceedings, Am. Soc. Hort. Sci. 75: 557-560. 1960.

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Watermelon Diseases on the Chicago Market. M. A. Smith. Proceedings, 14th Nat'l Conf. on Handling Perishable Agr.'l Commodities. pp. 16-20. Purdue Univ. Lafayette, Ind. Mar. 1-3, 1960.

6. MAINTAINING QUALITY OF VEGETABLES DURING TRANSIT

MQ

Problem: Changing containers, transit equipment, shortened rail and truck schedules and incentive rates for heavy loads have raised many questions concerning cooling rates, load patterns and protective services on product quality. Transit tests with the different vegetables from the various producing areas are needed to determine the most efficient methods of handling vegetables in transit to maintain market quality.

Program: A continuing program of applied research with precooling methods and techniques and transit services and equipment. The work involves about 4 professional Federal man-years annually at Beltsville, Maryland; Fresno, California; Orlando, Florida; East Lansing, Michigan; New York City; and Chicago, Illinois. The work with dry beans is in cooperation with Michigan State University.

Progress: Transit Temperature Requirements for "Vine Ripened" Tomatoes. To maintain quality in vine ripened tomatoes, control of temperature during transit to distant markets is essential. Determination of the lowest temperature that can be tolerated in transit by these tomatoes without causing chilling injury is equally important.

Transit temperatures in refrigerated trucks shipped from California were found to vary 10 to 15 degrees F. within the loads. These differences were caused by inadequate circulation of cold air through the loads. Air circulation was improved by placing a bulkhead at the front of the load to provide a return air passage to the cooling unit.

Ace tomatoes harvested with 1/3 or more color or pre-ripened 1 or 2 days at the shipping point until they were 1/3 or more colored, tolerated a simulated transit period of 5 days at 40°F. without evidence of chilling injury. Fruit shipped with less than 1/3 color showed mild "chilling" which delayed ripening almost 8 days.

Studies were continued at Beltsville, Md. to determine the most desirable pulp temperature to reach in precooling vine ripened tomatoes, and the extent of subsequent ripening during a 3 day simulated transit period.

Ripening was difficult to control in tomatoes having 40 to 50 percent color at harvest. Best results were obtained by precooling to 50°F. and holding at 50° during the simulated 3-day transit period. Fruits with 20 to 30 percent color at harvest ripened at a desirable rate if precooled to 60° and "transported" at 50° or if precooled to 50° or 55° and "transported" at either 50° or 55°. Fruits with only 10 to 15 percent color at harvest benefited by precooling only to 60° and "transporting" at 55°.

Air Shipment of Asparagus. An air shipment of asparagus from California packed in crates and shipped in an aluminum master container holding 70 crates was made from Stockton, California to New York. While temperatures did not increase greatly during the short transit period, the continuous warming from 38° to 53°F. emphasizes the importance of good hydrocooling and points to the need for improved handling methods to obtain lower transit temperatures.

Shipping Prepackaged Asparagus. Exploratory work on shipment of prepackaged California asparagus to eastern markets was started. Six test shipments initiated by the T. & F. Division in the Stockton, California area were examined at Beltsville. No marked extension of asparagus shelf life appears likely as a result of prepackaging. Packaging reduced weight loss but increased basal soft rot, a more serious type of deterioration. Decay of asparagus was highest in closed perforated poly bags and lowest on non-packaged bunches. Weight losses during shipment and a 3 to 5 day holding period at 50°F. after arrival averaged 7.7 percent for non-packaged asparagus, 5.7 percent in open-top poly bags, and 1.5 percent in closed poly bags. The open-top poly bag with 16 1/4 inch perforations appeared more promising than other types tested. Trimming asparagus from the standard 9-inches length to 7-inches to remove inedible tissue before prepacking was undesirable. The white basal fibrous tissue was much more resistant to soft-rot spoilage than the greener tissue higher on the stalk.

Hydrocooling Cantaloups. The rate of cooling at a flow rate of 12 gallons per minute per square foot of hydrocooler was about the same as faster flow rates which require more costly equipment confirming results obtained last season. Melon size also affects cooling rate. Size 36 and 27 melons had a half-cooling time of

approximately 20 minutes while the smaller size 45 melons had a half-cooling time of 11 minutes. At ambient summer temperatures of 81° to 92°F. following hydrocooling, the precooling achieved was lost in 70% of the volume of individual melons within 2 hours. This emphasized the importance of prompt loading and refrigeration after cooling. No appreciable differences in rate or manner of deterioration were found between melons that were hydrocooled and those that were room cooled.

Hydrocooling Lima Beans. Machine-shelled lima beans were cooled from an initial temperature of 70°F. to 38° to 49° during hydrocooling for 2 to 5 minutes in an ice-water bath (37° to 47°). Upon prepackaging into perforated polyethylene bags, the beans maintained good quality for 1 day at 70°, 3 days at 45°, and 6 days at 36°. A 100 ppm solution of chlortetracycline hydrochloride was of no commercial benefit in prolonging the shelf-life of packaged shelled lima beans.

Vacuum Cooling of Vegetables. California- A comparison of keeping quality of vacuum-cooled and hydrocooled celery was made during simulated transit and marketing periods. Crated bunches and prepackaged hearts were used. Minimum temperatures obtained in celery by vacuum cooling averaged approximately 45°F. Lower temperatures were obtained by hydrocooling. The condition of the celery after the holding period was as good following vacuum cooling as it was following hydrocooling. In both instances, top icing of the crated bunches was desirable during transit to preserve freshness. Top icing could not be used on the prepackaged hearts, nor was it necessary. The prepackaging celery hearts were adequately precooled by vacuum after packaging, which was more convenient than packaging after hydrocooling.

New York- The keeping quality of lettuce in cartons and corn in wirebound crates which had been vacuum-cooled in solidly loaded trailers was observed after transit and simulated marketing periods. The lettuce, after 12 to 36 hours in transit was in almost as good condition at destination as at origin, although decay increased from an average of 0.7 to 1.3 percent. After a 5-day holding period at 50°F, decay increased to only 3.8 percent.

At the shipping point the sugar content of sweet corn in one test was about 4 percent. After a transit period of 56 hours and a 3-day holding period at 50°F, the corn still retained about one-half of its sugar content. In another test, the sugar content of about 2 percent at origin was reduced to about 1.5 percent after a 60 hour transit period, and a 3-day holding period at 50°F.

Bunker Salting as Related to Transit Temperatures of Lettuce. Tests were completed to determine the effect of delayed initial salting of pre-iced railway refrigerator cars of lettuce. Average air blast temperatures and average transit temperatures of lettuce

in cars initially salted at either shipping point (Salinas) or the first re-icing station (Roseville) were about the same (35°F. for one pair of cars and 39° for two other pairs of cars). However, a considerable difference in air temperatures under the floor racks occurred at shipping point. Minimum air temperatures under the floor racks at shipping point average 26° in the cars initially salted at Salinas and 36° in the cars initially salted at Roseville. Delaying initial salting until the first re-icing station would reduce the chance of freezing lettuce near the bottom bunker position, particularly in well pre-cooled loads of lettuce that were delayed for some reason at shipping point. These results confirm those obtained last year.

Shipping Tomato Plants. Tests of bare-rooted tomato plants in polyethylene-lined crates shipped from Georgia to Canada were continued. Transit temperatures and arrival condition now have been recorded for 17 test shipments. Plants shipped bare-rooted in poly liners arrived in as good condition as those wrapped in moist paper with kraft paper. Plants in ice-bunker refrigerated truck were cooled to a desirable temperature (50°-60°F.) within 12 to 20 hours after loading, if loaded in a manner to allow circulation. Best results were obtained when liners were perforated with 32 1/2-inch holes and a 2 to 4-inch opening left at the top. Without this ventilation, condensation was excessive and there was some heating. Field survival of the bare-rooted plants has been excellent. Some commercial use is being made of this method of shipping tomato plants.

Field packing of bare-rooted plants using a mechanical harvester appears promising. This should provide cheaper plants to growers.

Protective Services for Winter Rail Shipments of Florida Celery to Canada. Rail refrigeration tests were conducted to establish the most practical and economical protective service to be used in conjunction with heater service for the prevention of freezing injury to celery en route to Canadian markets from Belle Glade, Florida. The results of eight test rail cars of hydrocooled celery showed little or no transit temperature differences between cars with pre-iced or dry bunker when each received 5 tons of top ice after loading. Because of unusually mild winter weather, no heater service was required and no freezing damage occurred in any of the test loads. In each test car, ample ice remained as bunker or top ice (at least 75 percent bunker and 50 percent top ice) at unloading. Therefore, it appears that savings of \$12 to \$50 could be obtained by modifying the present icing service, at least by eliminating the bunker ice during December, January and February. Elimination of bunker ice could result in further savings of \$11.50 per car which is charged to remove the bunker ice when portable heaters are placed in the bunkers.

Bulk Shipment of Dry Beans. Bulk shipping tests have demonstrated that beans can be moved in insulated rail cars with less quality loss and at lower cost than by current handling methods. Results of bulk rail shipment tests are now being prepared for publication.

Overseas shipping tests were initiated because of complaints from the European market relative to dry bean quality. One vessel loaded at Detroit and moving via the St. Lawrence Seaway was accompanied to point of discharge (London, England). Detailed quality measurements and information on moistures and temperature were made throughout the voyage. Two subsequent vessels traveling the same route were also studied. Preliminary results on the overseas shipment tests indicate that condensation from high humidity may increase moisture of surface beans and that lack of aeration may result in "musty" conditions of the bags on top and near the outside walls.

Effect of Loading Pattern on Transit Temperatures and Market Quality of Peas. High losses due to package breakage occur in rail shipments of peas. These studies were initiated to determine if changes in load patterns or top icing methods could be made which might reduce package breakage without adversely affecting transit temperatures and market quality of the peas. Three pairs of test cars of peas in bushel tubs were shipped during April 1960 from Delano, Calif. to eastern markets to compare transit temperatures in two types of loading patterns. The tubs in one car of each pair were loaded 5 high and 6 wide with tubs alternately inverted crosswise and lengthwise through the car. The tubs in the other car of each pair were loaded 5 high with stacks alternately 5 and 4 wide and alternately inverted lengthwise through the car. In both loading patterns, the tubs were loaded top to top and bottom to bottom. All cars were top-iced immediately after loading and re-top-iced once in transit. No bunker ice was used. Average transit temperatures were about 36°F. in all cars. Container breakage was serious in both types of loads. (See D. 8. Fresh Peas, for TF report on container damage aspects of the tests).

Transit Refrigeration of Artichokes. Rapid cooling and refrigeration near 32°F. favor the retention of quality and the reduction of decay in California artichokes shipped to distant markets. Cooling efficiency was not affected by (1) differences in water flow rates in the range of 7 to 21 gallons per minute per square foot of cooler area, (2) the addition of a wetting agent to the water, (3) placing the buds loosely or packed tightly in an unlidded container, or (4) packing the buds in a crate that was lidded before cooling but left without a paper liner. Half-cooling times for large (size-36) buds ranged from 16 to 21 minutes, and for small (size-72) buds ranged from 7 to 12 minutes. A cooperating shipper is now installing a hydrocooler to improve the quality of his artichokes.

Packed buds held for 48 hours at 46-53°F. before loading and top icing in the rail car (usual practice), were inferior to those placed in a refrigerated room (35-40°) immediately after packing, either with or without prior hydrocooling. Container types did not affect quality retention but top-iced lots were superior to those not top-iced during holding.

Fungicides have been quite effective in controlling decay of individual inoculated artichoke bracts, but neither Harven (1,500 or 3,000 ppm) nor captan (2,000 or 4,000 ppm) controlled decay of whole buds. The lack of control in the entire buds, as contrasted to the bracts, is attributed to the ineffectiveness of the fungicides against established field infection from which decay spreads during transit and marketing.

Plans: Rail shipping tests with lettuce have been completed but shipments by motor truck to domestic markets and by ship to Hawaii are planned if arrangements can be made. Vacuum cooling tests with New York lettuce and corn have been completed but further vacuum cooling tests will be made in California particularly with pre-packaged produce. The tomato plant shipping tests have been completed and a report is being prepared. The studies on loading methods with peas will be continued. Similar studies with celery are contemplated. Studies on artichokes, "vine ripened" tomatoes, and winter shipment of celery will be continued. The possibility of adding a fungicide to the water used in hydrocooling cantaloups will be investigated. It is planned to continue the work on dry beans, including shipment of California small white beans to New England processors.

Publications: Bruising Injury of Tomatoes. L. P. McColloch. Proceedings, 14th Nat'l Conf. on Handling Perishable Agr. Commodities. pp. 75-79. Purdue Univ. Lafayette, Ind. Mar. 1-3, 1960.

California Asparagus. Effect of Transit Environments on Market Quality. W. R. Barger, J. M. Harvey, J. K. Stewart, M. J. Ceponis and W. J. Lipton. USDA Marketing Research Report No. 428. September, 1960.

Hydrocooling of Cantaloups. J. K. Stewart, and W. J. Lipton. Produce Marketing. 3(5): 15-17. May 1960.

Factors Influencing Heat Loss in Cantaloups During Hydrocooling. J. K. Stewart, and W. J. Lipton. USDA Marketing Research Report No. 421. August 1960.

Effects of Cooling Method and Top-Icing on the Quality of Peas and Sweet Corn. J. K. Stewart and W. R. Barger. Proceedings Am. Soc. Hort. Sci. 75: 470-475. 1960.

Vacuum Cooling. J. Kaufman, B. A. Friedman, M. J. Jaffe and T. T. Hatton. Produce Marketing 3(8): 10-12. August, 1960.

Recent Research on Maintaining Quality of Fruits and Vegetables. J. M. Lutz. Proceedings, 14th Nat'l Conf. on Handling Perishable Agr'l Commodities 14: 123-131. Purdue Univ., Lafayette, Ind. Mar. 1-3, 1960.

7. CONTROL OF INSECTS IN PROCESSING PLANTS

MQ

Problem: A satisfactory method was needed to remove insects, insect fragments, and insect damaged kernels from fresh corn during processing.

Program: A 3-year program on the development of a suitable means for removing insects and other contaminants of sweet corn during processing for canning has been conducted under contract by the Ohio Agricultural Experiment Station at Wooster, Ohio.

Progress: Studies on washing of sweet corn to remove insect pests and their residues were divided into two aspects: a mechanical phase consisting of three operations--soak, airblast and spray-rinse; and a chemical phase consisting of the use of irritants and detergents. The following recommendations were developed:

1. Sweet corn for processing should be soaked for three minutes while being vigorously agitated. The soak water should contain 83.3 ppm pyrethrin and 2500 ppm detergent. It was found that a temperature of 100°F. was most effective in the removal of insect pests from sweet corn.

2. A three minute airblast treatment should follow the soaking operation. The ears should make at least two revolutions while in the air streams.

3. A thorough rinsing with 150 p.s.i. water should follow the airblast treatment. The rinse water should be fresh so as not to recontaminate the sweet corn. The ears should make at least two revolutions while under the sprays. The nozzles should be placed seven inches above the roller conveyor. The spray manifold should include at least two banks of full cone nozzles which deliver a square spray pattern and one bank of knife type nozzles. The number of nozzles will be determined by the width of the conveyor and the length necessary to accomplish at least two revolutions of the ears while under the spray.

4. These recommendations for washing sweet corn are merely an aid in packing a quality product free of contamination due to insects. It is highly urged that good production and handling practices precede the factory operations for satisfactory control of insects infecting this crop.

Plans: This study has been completed. Results will be published by the contractor.

D. Transportation, Storage and Packaging

8. IMPROVED LOADING METHODS

TF

Problem: Increasing freight, protective service, and labor costs, moulding; losses from spoilage, damage and reduced shelf life because of ineffective refrigeration and ventilation during transportation have resulted in substantial losses to shippers, receivers and carriers, and have greatly increased marketing costs for many agricultural products in recent years. More efficient loading methods that can be used with little or no additional cost to shippers can provide better protection for containers and products, facilitate better refrigeration and ventilation during transit, more efficient preshipment and postshipment handling methods and more effective use of available loading space in the transportation vehicles, leading to reduced per-package transportation, refrigeration and handling costs.

Program: This long-term economic-engineering study involves test shipments by rail and truck from various producing areas throughout the country to different terminal markets to develop, test, and evaluate new loading patterns, load securing equipment, measurement of container and product damage, air velocity, temperature differentials, and labor requirements for loading and unloading. It is carried out from Washington, D. C. and Orlando, Fla., with the informal cooperation of shippers, receivers, railroads, truck lines, container and loading equipment manufacturers, state experiment stations and other interested groups, and involves about 3 professional Federal man-years annually.

Progress: Onions. Limited exploratory research to determine the need for and the problems and possibilities of developing better loading methods for rail and truck shipments of 25- and 50-lb. bags of onions was begun late in the 1960 shipping season for Texas onions. This preliminary work indicated a real need for better, more stable loading patterns for rail shipments that will facilitate better air movement through the loads during transit. This need has become more acute in recent years with most shipments being loaded to greater heights by shippers to take advantage of lower freight rates on the heavier loads. Several new loading patterns were developed, but the shipping season ended before any shipping tests could be made with them. A new loading pattern for ventilated truck shipments was also developed. Only one long-distance truck shipment was made with it. The results indicated that the new pattern would greatly increase the flow of air through the load, and that the load was highly stable in transit.

Fresh Peas. Exploratory work to determine the causes for and means of preventing excessive container and commodity damage and ways of improving refrigeration of rail shipments of fresh peas in bushel tub baskets was begun in April 1960 at the request of the American Veneer Package Association and the Association of American Railroads. Sufficient information was developed in a 6-week study of about 16 shipping tests for purposes of developing a more comprehensive research plan for additional work in the 1961 shipping season for California peas. This preliminary research indicated that the excessive transit loss and damage in rail shipments of this commodity was due in large measure to 3 principal correctable causes; (1) use of comparatively weak and fragile solid-bottom veneer baskets, (2) an inherently unstable loading pattern, and (3) excessive and uneven applications of crushed ice to the loads. (See C.6. Effect of Loading Pattern, etc., for MQ. report on temperature and quality aspects of the tests).

Watermelons. Research was also begun during the year to determine the feasibility of heavier loading of rail shipments of watermelons to reduce per-melon transportation costs. Results obtained from about 46 test shipments indicated that melon damage in loads 50 to 75 percent heavier than conventional loads was about the same rate percentagewise as damage in the lighter loads. Under present railroad tariff provisions, shippers and receivers can save as much as \$150 per car on freight costs from central Florida points to New York City. The southeastern railroads are giving consideration to extending to watermelons the application of per-car or multiple-minimum freight rates, which should provide substantially greater savings in per-melon and overall transportation costs, if this research should reveal that heavier loading is feasible from the damage standpoint. In conjunction with these heavier loaded shipping tests, trials were made of a new low-cost and highly efficient floor and endwall cushioning material made of expanded polystyrene foam. These tests gave very promising results, both from the standpoints of melon protection and in providing for better ventilation of the loads during transit.

Plans: A series of laboratory tests to determine the value of a number of different innovations in the design and fabrication of solid-bottom, recessed-cover pea baskets in strengthening these containers will be conducted at the Forest Products Laboratory in Madison, Wisconsin in the fall of 1960. Additional shipping tests will be made during 1961 to develop and test improved loading patterns for onions and fresh peas and heavier loading of watermelons.

9. IMPROVED CONSUMER PACKAGES, SHIPPING CONTAINERS, AND METHODS OF PACKAGING

TF

Problem: High costs of labor, packaging materials, and transportation; high waste and spoilage losses and deterioration of product quality; and frequent expressions of consumer dissatisfaction with some prepackaged vegetables emphasize the need for improving the packaging of fresh vegetables at lowest possible costs.

Program: A varied and continuing program--in terms of shifting attention from a commodity on which research has been completed to other vegetables--to (1) develop new or improved consumer packages and shipping containers; (2) evaluate packages, containers and packaging materials; (3) determine at which point in the marketing system the packaging can be done most effectively; (4) improve efficiency of packaging methods; and (5) investigate the needs for and benefits of container standardization and simplification, carried on in cooperation with container manufacturers and growers and distributors in the main vegetable producing areas and in the principal markets, and involving 2 professional Federal man-years annually.

Progress: Asparagus. Early limited experiments in Washington State indicated that 7-inch asparagus trimmed to all edible 5-inch portions and packaged in polyethylene bags could be safely shipped and marketed on nearby markets (250 miles), providing that the asparagus was carefully refrigerated at all stages of distribution. Trimming the 7-inch spears to 5 inches reduced the weight of the asparagus about 35 percent and represented a potential savings in shipping weight and refrigeration and space requirements. However, the additional materials and labor cost amounted to 3.4 cents per pound above the cost of the conventional bunch pack in the pyramid crate.

In 1960, six controlled rail test shipments from California to East Coast terminal markets were initiated. Spears 9 inches and 7 inches in length were packed in five different types of packages. These were: (1) Closed, perforated 1 mil polyethylene bag; (2) open, perforated 1 mil polyethylene bag (exposed tips); (3) non-perforated wrap of 1 mil polyethylene film (exposed tips); (4) waxed folding paperboard carton; and (5) non-perforated band wrap of irradiated polyethylene shrink film (tips and bottoms of butt exposed).

The controls used to compare to condition of the asparagus were either bunched or loose spears. Half of the asparagus (both 7-inch and 9-inch) was trimmed to all green and the other half had the conventional $\frac{1}{2}$ to 2 inches of white butt. The test shipments and subsequent holding periods of 5 to 7 days at 40° and 50°F. gave the following results: (1) Spears trimmed to all green lengths were much more perishable; and more susceptible to decay than the

spears with white butts; (2) the open and perforated polyethylene bag that allowed the tips to be exposed seemed to be the best packaging method; (3) packaging asparagus in plastic film reduced weight loss significantly.

The cost of materials used for prepackaging 30 pounds of asparagus in 2-pound bags was estimated at 69 cents as compared to 46 cents for the conventional loose pack, and manually prepackaging a crate of asparagus would involve a direct labor cost of about 35 cents per crate more.

In addition to the cross country shipping tests of 7- and 9-inch spears, researchers also conducted limited experiments in Washington State to determine the economic feasibility of marketing No. 2 asparagus spears cut into $1\frac{1}{2}$ -inch to 2-inch lengths and jumble-packed in 1-pound polyethylene bags closed with a heat seal. The packaged asparagus was sold in local markets where the reaction was mixed. The manager of one retail outlet reordered. Another thought a pound of edible asparagus in a package was too much. After four days on display the packaged asparagus was still in good condition.

Another study investigated the use of polyethylene liners for the standard wood pyramid asparagus crate. Such a liner may offer opportunities for reducing the tare weight of the standard pack, thereby saving transportation costs, and also increase the marketing life of the asparagus. In cooperation with the Market Quality Division, storage tests were conducted with polyethylene liners with and without perforations and with and without water absorbing liners. The asparagus was stored for 12 days. Only the asparagus in test boxes with non-perforated polyethylene liners showed off-odors, or off-flavors. The asparagus with pinhole or $1/4$ -inch perforated liners held up about as well as the conventional asparagus boxes used as checks.

Cauliflower. Substantial savings in marketing costs obtained by trimming wrapper leaves from California cauliflower and packaging the all-edible heads at point of production were reported to the Committee last year. A publication detailing the findings was issued in July 1960. Numerous inquiries for this publication have been received from other cauliflower producing areas.

Celery. In 1959-60, preliminary test shipments of prepackaged celery hearts were made from the Belle Glade area of Florida to New York. The celery was hand-trimmed, washed and packed in waxed chipboard trays. The trays were overwrapped in either 300-gage K203 cellophane or in biaxially oriented polyethylene. Celery stalks were processed in the same manner as the hearts except that they were packed in unclosed polyethylene bags or in shrinkable polyethylene film. The bags or overwrapped trays were packed in wirebound master containers and vacuum cooled to about 38 degrees in approximately 30 minutes.

All prepackaged celery in these tests arrived at terminal in satisfactory condition. The cellophane overwrapped trays usually were open or partially open, and sometimes torn. The trays in shrinkable polyethylene and the stalks wrapped in shrinkable polyethylene arrived with tight seals and in excellent condition.

Green Beans. In 1959-60 five small test shipments of prepackaged green beans were made from Belle Glade, Fla. to New York. The beans were hand selected, graded, and packaged in perforated polyethylene and polymer coated cellophane bags. They were packed in wirebound master containers, vacuum cooled to 38 degrees, and shipped under standard refrigeration. In all these preliminary test shipments, terminal and retail arrival condition was excellent. The beans were dry, there was no condensation in the bags, and they displayed well lying flat. On the basis of these tests, a commercial packaging line is being installed which will permit larger scale test shipments.

Sweet Corn. During the spring of 1960, 10 experimental test shipments of sweet corn were made from Florida to eastern markets. The corn was processed in various ways, packed in different types of trays and films, and either hydrocooled or vacuum cooled. The trays were molded pulpboard trays and folding chipboard trays. The films for overwrapping were polymer coated cellophane and irradiated shrinkable film.

Various amounts of husk were stripped off. The corn was cut to different lengths, wet before and after cooling, and shipped under top ice or on top of ice. In several shipments denting of the corn kernels occurred. In two shipments the corn arrived in very good condition and with excellent appearance.

Lettuce. Exploratory packing and shipping tests were undertaken to determine the economic feasibility of trimming off the outer leaves of lettuce and prepackaging the trimmed heads at point of production. Although the trimming and packaging added somewhat to the labor and materials costs, it is anticipated that these increases can be more than offset by lower transportation, handling, and retailing costs. The trimming was found to reduce the weight of each shipping container by approximately 15 pounds. In a conventional carload of 640 containers, the overall weight reduction was estimated at 9600 pounds and the savings in freight around \$250 in a haul from California to New York.

Researchers also sought an attractive package that would shield the lettuce from damage and enhance its appearance and condition at time of purchase, thus increasing its salability.

In addition to work at the point of production, researchers also cooperated with a large corporate grocery chain in experimenting with packaging lettuce at terminal market level. Trimmed heads of lettuce were overwrapped with shrinkable film and passed through a heat tunnel. The film shrank tightly around the lettuce forming a trim package.

Plans: Work will be continued and increased emphasis will be given to development of packages and containers and methods of prepackaging vegetables at the terminal market and at the point of production. This includes research on prepackaging asparagus, broccoli, sweet corn, green beans, celery, leafy vegetables, sweet potatoes, and tomatoes.

Attention will also be given to developing improved shipping containers for vegetables, such as the moisture-resistant fiber-board boxes currently being developed and tested.

Publications: Packaging California Cauliflower. John L. Ginn and Philip W. Hale. USDA Marketing Research Report No. 414. July 1960.

Progress on Packaging Florida Green Beans and Sweet Corn. John L. Ginn, AMS. Processed Paper Presented at Produce Packaging Association Convention, Miami, Florida. September 13, 1960.

Prepackaging Fresh Fruits and Vegetables. Donald R. Stokes, AMS. Texas Citrus and Vegetable Growers and Shippers Yearbook. 1960.

Better Packaging for Bigger Sales. Donald R. Stokes, AMS. United Fresh Fruit and Vegetable Association Yearbook. 1960.

Prepackaging Produce--What's New?--What's Ahead? Donald R. Stokes, AMS. Processed Paper Presented before Canadian Fruit Wholesalers' Association, Quebec, Canada. February 8-10, 1960.

New Source, Terminal, and Central Warehouse Packaging Practices. Donald R. Stokes, AMS. Processed Paper Presented at National Produce Executives' Conference, Chicago Ill. May 24, 1960.

Produce Packaging Trends in the 60's. Donald R. Stokes, AMS. Processed Paper Presented at Merchandising and Management Conference of United Fresh Fruit and Vegetable Association, Chicago, Ill. August 22, 1960.

E. Equipment, Facilities, Methods and Firm Efficiency

10. IMPROVED METHODS, EQUIPMENT, PLANT LAYOUT AND DESIGN FOR HANDLING, PACKING, AND PROCESSING FRESH VEGETABLES TF,FS

Problem: There is a need for more efficient work methods, devices, equipment and improved facilities for precooling, conditioning, handling, and preparing vegetables for market at terminal and shipping points so as to increase the efficiency of labor, prolong storage and shelf life of vegetables, and reduce bruises and injuries.

Program: A long-term research program conducted by the Washington Office on terminal markets and by the Gainesville, Fla., and Athens, Ga., field offices at shipping points, in commercial packing plants and laboratory facilities of the University of Florida, in cooperation with the Florida Agricultural Experiment Station and the Georgia Agricultural Experiment Station on work at shipping points, and with the USDA Marketing Economics and Market Quality Research Divisions, at the rate of 2 professional Federal man-years annually.

Progress: Handling and Packing Tomatoes in Terminal Markets. Field work involving work measurement studies to obtain complete data on sorting, packing, and related operations associated with repacking tomatoes has been completed. Data were collected at 3 plants during the year. Different work methods were observed and where possible, data were obtained for at least 2 different crew sizes for each of the sorting and tray filling systems. Tables of basic labor requirements for these operations have been prepared. Preliminary estimates of labor costs for sorting range from \$0.95 to \$2.40 per thousand pounds for the methods covered in the study. Labor for filling and packing trays amounted to \$4.35 per thousand trays for the most efficient method, and \$6.65 for the least efficient method. Both methods involved the use of packing bins.

Studies of physical damage to tomatoes caused by inplant handling operations were made. It was found that much of the bruise damage resulting from handling (mainly while sorting) was not outwardly detectable. If tomatoes are bruised during the early stages of ripening, the jelly fails to develop in the damaged seed cavities and becomes dry. This impairs the flavor.

Handling and Packing Vegetables at Concentrations Points. In Florida data on process-flow were obtained for nine tomato packing-houses and layouts (sufficient for layout drawings) were prepared of three packinghouses. Information regarding equipment, crew sizes, and related packinghouse information also was obtained. It was found that the labor force in a typical packinghouse for mature-green tomatoes was divided as follows: (1) 50 percent for sorting; (2) 30 percent for packaging; and (3) 20 percent for other activities. Initial research has been directed toward improving packaging methods. Element descriptions were written and time study

data were obtained on typical manual filling and weighing operations for mature-green tomatoes jumble packed in 40- and 60-pound containers; on forming 50-pound capacity, two-piece, telescope-type cartons; and on closing wirebound boxes with automatic and semi-automatic machines. Cost data, needed for future cost analysis, were obtained for some items of equipment.

Precooling Vegetables. Through laboratory tests, the effective thermal diffusivity and conductivity values of whole specimens were determined for sweet corn. This information should enable designers and operators of precooling systems to determine the maximum cooling rates possible for products of various sizes at various cooling medium temperatures. Laboratory tests also were initiated to determine the thermal conductivity of the separate components of selected vegetables. Progress was limited to the development of the test procedure and calibration of the apparatus and instrumentation used.

In an experimental hydrocooler, tests were conducted to compare the cooling rates of sweet corn under various treatments. Surface coefficients of heat transfer also were estimated.

Development and Testing of Pallet Bins and Boxes. Work at the Forest Products Laboratory (FS) to obtain fundamental data relative to pallet design and manufacture for use by shippers and manufacturers, and for development of a rational method of pallet design, included a number of studies that, while not directly involving vegetables, will aid in resolving broad problems in use of pallet containers. These included development of a method for calculating the load-carrying capacity of top deck boards of three-stringer general-purpose pallets and incorporation into a simple circular calculator; determination by test of the desirable construction features of apple harvesting wood bin pallets which showed that for 10 styles tested in simulated weathering and rough-handling, three performed well, four were acceptable, and three failed in test. It appeared that vertical sideboards, rather than large triangular corner posts, and many assembly nails are desirable features. In cooperation with AMS, eight designs of pallet boxes for shipping apples and citrus fruits to market in bulk were reviewed and changes proposed. A Wood Pallet Promotion Clinic was held in September, 1959.

Plans: A manuscript covering research on handling and packing tomatoes in terminal markets to be prepared for Department publication will include: (1) An economic cost analysis, based on the labor and equipment requirements for sorting, tray packing, place packing and handling operations; (2) a comparative cost analysis of efficient packaging system for 3 different volume levels developed through synthesis from component operations considered in the study; (3) an evaluation of the types of physical damage to tomatoes resulting from rough handling at sorting and packing lines; and (4) recommendations for temperature and humidity levels required for proper ripening of mature-green tomatoes.

At concentration points, work to develop improvements to the manual filling and weighing station for jumble packed mature-green tomatoes will be continued. An interim report covering methods of manually jumble packing mature-green tomatoes will be prepared. In-plant handling methods will be studied to determine for what uses and under what conditions powered trucks would result in a net savings over the use of hand trucks. Three-dimensioned models of commonly used packinghouse machinery will be made for use in studying packinghouse layout problems and developing recommendations for improved layouts. Studies will be made of the automatic weigh-fill machine for packing mature-green tomatoes. Comparisons will be made of this method and the manual method for identical packs.

Thermal conductivity studies of the separate components of fresh vegetables will be continued. Work on designing a wind tunnel for air cooling, to be installed in the Laboratory at Athens, Georgia, will be initiated.

If funds become available, work will be initiated under a research contract on designing and testing of pallet boxes and auxiliary equipment for the handling and ripening of tomatoes.

The Forest Products Laboratory plans to conduct simulated weathering and rough handling tests on at least 2 more of each of 10 styles of wood bin pallets, including effects of water-repellent treatments. Observation and participation in shipping tests of apples and citrus fruits in bulk will be continued, along with design of realistic tests to simulate the stresses and impacts of actual use. This should lead to useful information applicable to similar commodities. Effort will be made to develop a lateral-impact test for pallet fasteners that will simulate stresses imposed by ordinary rough handling, and compare pallet joints made with machine-driven nails to those made with hand-driven nails.

Publications: Bin Pallets for Agricultural Products. T. B. Heebink. FPL Report No. 2115. June 1958.

Load-Carrying Capacity of Deck Boards for General-Purpose Pallets. T. B. Heebink. FPL Report No. 2153. August 1959.

Preservatives for Wood Pallets. J. O. Blew, Jr. FPL Report No. 2166. October 1959.

F. Costs, Margins, and Organization of the Marketing System

11. EVALUATION OF PROCESSING AS A MARKET FOR SOUTHERN VEGETABLES ME

Problem: Vegetable growers and processors need information about the economic feasibility of processing vegetables grown in the South. Growers need more information to assist them in evaluating processing as a market outlet for vegetables.

Program: A 3- to 4-year program of applied research being carried out in cooperation with the North Carolina, Georgia, and Louisiana Agricultural Experiment Stations as a phase of the Southern Regional Vegetable Marketing Research project, involving two to three professional Federal man-years annually, and located at Raleigh, North Carolina; Griffin, Georgia; Gainesville, Florida; and Washington D.C.

Progress: Detailed studies were made of sweetpotato canning in plants in Louisiana to determine the effect on cost of such factors as size of plant, length of operating season, type of equipment used, and method of performing various jobs within the plant. Preliminary tabulations show that trimming and filling require about 75 percent of the production line labor. Trimming and filling labor costs were lower by 24 cents per case of number 303 cans when the two jobs were performed separately than when they were combined.

Plans: The study of canning costs for sweetpotatoes will be completed this year. An increase in appropriations was made for an evaluation of the potential for processing vegetables grown in the Southeast. An office was opened at Griffin, Georgia, to initiate this work in cooperation with the Georgia and other Agricultural Experiment Stations in the Southeast. This work is just getting underway.

12. CHANGES IN METHODS OF MARKETING

ME

Problem: Vegetable industry leaders need more accurate information on the changes taking place in wholesale markets for fruits and vegetables to evaluate the impacts of these changes on the vegetable industry and to assist in making decisions and recommendations for adjustments to meet these changes.

Program: A 3- to 4-year research program involving about four professional federal man-years annually in cooperation with the Agricultural Experiment Stations in numerous states and through contract studies in the San Francisco market area by the University of California, Berkeley, California and in the Pittsburgh market by Midwest Research Institute, Kansas City, Missouri. The following Agricultural Experiment Stations are cooperating: Wisconsin, West Virginia, Kentucky, Maine, Montana, Nebraska, New York, Utah, New Mexico, Louisiana, Arkansas, South Carolina, Oklahoma, and Minnesota.

The present organization and status of 52 wholesale fruit and vegetable markets throughout the country were included in the studies.

Progress: Information obtained from approximately 2800 firms has been analyzed in part and a publication issued. Some of the findings and indications obtained under the study are as follows: Direct buying by corporate and voluntary chain stores has increased markedly in the postwar years as many more chains grew to a size which made such buying attractive to them. Direct buying can be

expected to continue to increase as other corporate and voluntary chains grow to this size. This will mean an increased demand for more uniform products. The size of the lot purchased by individual organizations will increase, on the average. It will be increasingly difficult to dispose of variable lots, small lots, and lots of odd size, grade, color, etc. This may mean increasing emphasis on large packing and shipping operations which can put up uniform lots which will meet the specifications of some part of the chain store market. Markets may tend to become more segmented, as more direct buyers line up a small number of shippers with whom they deal regularly. Volume control will become more important, as the market for supplies which cannot be sold to direct buyers shrinks, and the effect of each additional carload added to or withdrawn from this market will become more pronounced. Wide swings in supply may cause wider swings in price than formerly and it will be more difficult to clean up supplies in a market because the number of buyers will have declined.

Analyses in process will provide the basis for description of the structure of wholesale markets and an analysis of the role of terminal markets in the years ahead.

Plans: The analyses will be completed, and reports prepared and published.

Publications: Chainstore Merchandising and Procurement Practices--The Changing Retail Market for Fresh Fruits and Vegetables. William E. Folz and Alden C. Manchester. USDA Marketing Research Report No. 417. July 1960.

13. GRADE AND SIZE STANDARDS FOR MATURE GREEN TOMATOES

ME

Problem: Information relating to the economic significance of the numerous grade and size designations now in use for mature green tomatoes is needed to assist in reducing the operational difficulties encountered in the marketing process.

Program: This research was conducted in 11 large supermarkets to determine the importance consumers attach to grade and size characteristics of mature green tomatoes. It involves 1 professional Federal man-year annually.

Progress: The field work for the project was conducted in 11 supermarkets in the Dayton, Ohio market area in May 1960. Matched-lot displays were used to determine (1) the effect of size on sales; (2) the effect of grade on sales; and (3) the combined effect of grade and size on sales.

Each display contained US No. 1, size 6 x 7 tomatoes and tomatoes of one of 11 other grade and size designations. From the

11 basic test situations introduced during the study, comparisons of sales can be made between US No. 1, 2, and 3 grades and from sizes from 5 x 6 to 7 x 8.

Plans: Field work has been completed. A report of the findings will be published jointly by the Florida Agricultural Experiment Station and AMS. This will complete the project.

14. IMPROVED PRICING METHODS

FCS

Problem: Improved pricing plans and grower payment methods are needed to more accurately reflect changing market requirements back to growers and grower organizations so as to better balance supplies with demand. Changing industry organization and procurement practices required by mass distribution are bringing about more complex product specifications, and has altered pricing techniques which reduce the effectiveness of conventional pricing methods.

Program: This continuing long-range program of applied research, part of which is contributing to the Western Regional Project WM-38, is conducted in major production areas and involves about one professional Federal man-year annually.

Progress: Current work in this area involves (1) a comparison of returns to growers of selected fruits and vegetables from various grower payment methods; and (2) an analysis of the impact of bargaining associations on the market structure and behavior of the fruit and vegetable processing industry. Neither phase has progressed to a stage where findings can be reported.

Again at the request of growers, a Fourth National Conference on Fruit and Vegetable Bargaining Cooperatives was held in January 1960 at Atlanta, and a report of proceedings was prepared and distributed.

Plans: Research on grower payment methods and bargaining associations will continue. In addition, work will be initiated on a study to determine and analyze factors affecting wholesale prices received for Florida celery and celery produced in other regions. Publications are planned for each area of research conducted under this program.

Publications: Co-op Grower Payment Methods in a Changing Market. C. B. Markeson. News for Farmer Cooperatives. February 1960.

Proceedings of the Fourth National Conference on Fruit and Vegetable Bargaining Cooperatives. FCS Unnumbered Report. January 1960.

Some Facts About Fruit and Vegetable Bargaining Cooperatives. W. M. McMillan FCS Information 11. December 1959.

G. Price, Supply and Consumption

15. PRICE, SUPPLY, DEMAND AND OUTLOOK ANALYSIS FOR VEGETABLES AEC

Problem: Determining and evaluating those factors which influence the supply, demand and price of vegetables in both the short-run and the long-run; compiling and maintaining statistical series on stocks, production, foreign trade, consumption and prices; analyzing those data and preparing reports; and servicing requests for information.

Program: A continuing program involving frequent appraisals of the current and prospective situation for vegetables, conducted in Washington, D. C., and involving less than 1 professional Federal man-year annually.

Progress: During the past year major effort was devoted to continuing appraisals of the current and prospective short-run supply, demand and price situation for fresh and processed vegetables, dry edible beans, and dry field peas. Results of these appraisals were published in quarterly issues of the Vegetable Situation and the National Food Situation, and brief summaries in monthly issues of the Demand and Price Situation.

Data were summarized, from 1935 to 1958, and an article published in the April 1960 issue of the Vegetable Situation, on "Trends in the Geographic Pattern of Production of Tomatoes for Processing". Most striking developments over the two decades were the sharp increase in total production, and the rapid gain in importance of the West. Total production of tomatoes for processing more than doubled from 1935-38 to 1955-58. Production in the Western Region increased more than fivefold, and its share of national production gained from 24 to 63 percent of the total. Production declined in the South Atlantic and South Central Regions. Despite substantial increases in tonnage, the North Central and North Atlantic Regions declined in relative importance.

Another article published in the July 1960 Vegetable Situation deals with the rapid growth during the past 10 years of the frozen vegetable industry, and examines the pattern of growth for retail and institutional packs of a number of items. During the decade the retail pack more than doubled, from 364 million pounds in 1949 to 888 million pounds in 1959. But the institutional pack increased even more rapidly, from 200 million to 738 million pounds. About 45 percent of the total frozen pack was put up in institutional and bulk containers in 1959 compared with 35 percent in 1949.

A study was made and an article published in the October 1960 issue of the Vegetable Situation on "Trends in the Geographic Pattern of Production of Snap Beans for Processing". Total production increased about $3\frac{1}{2}$ times from 1935-38 to 1955-58, with substantial tonnage increases in all regions. However, the West, with more

than a fivefold expansion in production gained relative to the other regions. The West increased its share of national production from 24 to 37 percent of the total. The North Atlantic and South Central areas about held their own at 22 and 10 percent of the U. S. total, while the North Central and South Atlantic Regions declined in relative importance.

An article in the November 1960 National Food Situation examines the changes in patterns of vegetable consumption in the post-war period. Total consumption of commercially produced vegetables per person has remained remarkably stable, at about 200 pounds a year, fresh equivalent. But there has been a big growth in use of processed items, often at the expense of fresh.

A manuscript is being prepared on Vegetable Consumption Trends and Patterns. The information is primarily for the use of Federal-State extension people working with marketing agencies.

Plans: The manuscript on consumption trends and patterns will be completed and published. Analysis and periodic reviews of the current and prospective situation for fresh and processed vegetables will be continued. Statistical series will be revised as benchmark data from the 1959 Census become available.

Publications: The Vegetable Situation. AMS, Washington, D. C.
(Quarterly) The National Food Situation. AMS, Washington D. C.
(Quarterly) The Demand and Price Situation. AMS, Washington D. C.
(Monthly).

H. Foreign Competition and Market Analyses

16. FOREIGN TRADE IN VEGETABLES

FAS

Problem: The United States is a net exporter of both fresh and processed vegetables. The principal importing countries are Canada, Cuba, Mexico, and Venezuela. There are no major trade problems with Canada. The United Kingdom has liberalized imports of both fresh and processed vegetables. There is serious competition from imports of certain winter vegetables grown in Mexico and Cuba.

Program: Long-term programs aimed at expanding nearby markets are continuing and a new program to develop a market for winter vegetables in Northern Europe will be started. Periodic competition studies are made of the areas competing with the U. S. vegetable industry, and analysis of the potential market in Northern Europe will be made. This work involves approximately one professional Federal man-year annually, and it is carried out in cooperation with U. S. trade groups, foreign importers, and State Department officials, both in Washington and in the Foreign Service.

Progress: Competition studies of the winter vegetable industries in Cuba and Mexico and the Italian tomato processing industry have been made.

Plans: A program of analyzing the potential demand for and promoting the sale of winter vegetables in Northern Europe will be carried out in cooperation with U. S. vegetable growers' associations. An experimental plan to develop a crop reporting system and to report the monthly plantings of winter vegetables in Mexico will be initiated this season.

Publications: Italian Tomato Processing Industry. FFV 1-60. April, 1960. Winter Vegetables in Mexico. FFV 2-60. July, 1960.

